Wetlands and Construction: An opportunity for Berlin-Brandenburg

Ed. Material Cultures + Bauhaus Earth, in collaboration with Experimental

Preface

This report was developed collaboratively by Material Cultures and Bauhaus Earth as part of the Bauhaus Earth Fellowship Programme, following an analysis of the Brandenburg region's paludiculture and biobased material supply chains and production cycles. Our research project aims to contribute to the development of a new architectural vernacular: one whose aesthetics are rooted in circular and bio-based principles. We seek to demonstrate the potency of cross-industry and interdisciplinary collaborations, and the critical urgency of addressing the conditions and health of our landscapes. This research project responds to excerpt 8 of the state of Brandenburg's ten point programme which states that "broad communication and public relations are required to accompany any peatland protection activities." [1]

At Material Cultures, our research along the supply chains of the materials we specify has taken us to the different landscapes in which biobased materials can be cultivated. It's in the woods, fields and wetlands that we have begun to explore the consequences of cultivation, for the environment, for the people who work the land, and for the non-human species that depend on it.

1 Ministerium für Landwirtschaft,Umwelt und Klimaschutz, 2023. Moorschutzprogramm Brandenburg, p.36

Glossary

Alluvial: Sediments deposited by running water

Anoxic: A place or environment, lacking or without oxygen, such as in water saturated **peat** soil

Biomass: Harvested plant material

Bog: A type of **peat** accumulating wetland fed by rainwater, and therefore typically quite nutrient poor. Bogs are more likely to have an acidic water composition.

Carr: A wetland composed predominantly of woody shrubs, often formed during the **succession** of a wetland into woodland.

Coppice: The practice of stimulating tree growth by periodically cutting the stem near to the ground, after which the tree will develop a stool and grow multiple stems.

Culm: The botanical term for the individual above ground stems of a grass or sedge.

Ecosystem Services: See *Natural Capital.*

Fen: A type of **peat** accumulating wetland fed by moving water (ground or surface), and therefore typically mineral and nutrient rich. Fens are more likely to have an alkaline water composition, but become more acidic and can even transition into bogs if **peat** accumulation is so much that it blocks ground water supply.

Marsh: A wetland composed predominantly of herbaceous plant species.

Mire: A **peatland** that is actively forming **peat**.

Monocultural/Monotype: The growth (naturally or artificially) and dominance of a single species.

Natural capital: The attribution of financial value onto goods and **ecosystem services** performed by nature. It is a young and complex phenomenon, but is widely considered as a way to incentivise better land management practices through certificate and credit systems that reward metrics such as carbon retention or **peatland rewetting** etc.

Paludiculture: The productive land use of wet or **rewetted peatland**, which allows the cultivation of wetland crops for commercial use whilst preserving peat soil.

Peat: The accumulation of partially decomposed plant and organic matter that occurs in the **anoxic** state of the waterlogged soil found in **peatlands.**

Peatland: A type of wetland with **peat** deposits. When wet, they are very effective carbon stores but emit vast quantities of carbon dioxide when dry as observed during the industrial drainage of peatlands for agriculture and other purposes.

Perennial: A plant that lives for several years and therefore does not need to be annually replanted.

Rewetting: The permanent resaturation and flooding of drained peatlands.

Rhizome: A **perennial** subterranean plant stem that grows horizontally, and emits roots and shoots from its nodes.The plant's above ground **biomass** often dies back in the winter, returning its starches and proteins to the rhizome which is then able to resprout in the spring.

Succession: The natural process through which a landscape, and its ecology, changes over time into a new type of habitat, i.e pasture to woodland.

Swamp: A forested wetland, occurring in both freshwater and saltwater systems.

Wet meadow: A wetland condition in which the ground is waterlogged partially or totally during the growing season, which prevents the establishment of trees. Some experts consider wet meadows as a type of wetland distinct from **marshes**

Summary

To achieve the European Union's (EU) 2050 target to become climate neutral, under European law EU member states must reduce greenhouse gas emissions by at least 55% by 2030. Two factors essential to meeting this target are the reduction of greenhouse gas (GHG) emissions from drained peatlands and the reduction of emissions from the construction industry. Global peatlands provide an essential store for carbon, capturing twice as much carbon as all the forests on earth. However, once degraded, peatlands become a net emitter, with carbon captured by these soils released as climate change-inducing GHG emissions: 5% of global anthropogenic CO_2 emissions are caused by damaged peatlands[2]. 10% of Europe's land surface is peatland, but up to 50% of the EU's peatlands are degraded[3]. At a national level, this rate can reach even higher. In Germany, more than 95% of peatlands have been drained[4]. In parallel, the construction sector, through material extraction, product manufacture, and new-build and renovation, accounts for an estimated 5-12% of EU nations' GHG emissions[5]. Carbon capturing materials and localised production are vital in reducing this figure.

This report by Material Cultures in collaboration with Bauhaus Earth examines how environmentally responsible paludiculture (wetland farming) cultivation can provide a source of renewable, carbon-capturing construction materials whilst regenerating peatland landscapes. Using the Sernitzmoor area within the German state of Brandenburg as a case study, this report explores how a land practice which promotes peatland carbon capture and the decarbonisation of the construction sector could be implemented at scale to deliver climatic, ecological and economic benefits.

2 International Union for Conservation of Nature. 2021. "Peatlands and Climate Change." IUCN Issues Brief.
3 UN Environment Program World Conservation Monitoring Centre. 2021 "Research Reveals a Quarter of Europe's Peatlands are Degraded, Ahead of Key Climate and Biodiversity Summits." Retrieved June 2023, from https://www.unep-wcmc.org/en/news/research-reveals-a-quarter-of-europes-peatlands-are-degraded--ahead-of-key-climate-and-biodiversity-summits
4 Global Peatlands Initiative. 2021. "Germany has Published its First-ever National Peatland Protection Strategy." Retrieved June 2023, from https://globalpeatlands.org/germany-has-published-its-first-ever-national-peatland-protection-strategy
5 European Commission – Internal Market, Industry, Entrepreneurship and SMEs. "Buildings and Construction." Retrieved June 2023, from https://single-market-economy.ec.europa.eu/industry/sustainability/buildings-and-construction_en#:~:text=The%20construction%20sector%20is%20responsible,of%20total%20national%20GHG%20emissions

If current peatland emissions continue, they will consume 41% of the remaining carbon budget to restrict global warming below +1.5 °C. Despite this forecast, peatlands can be restored by 'rewetting' drained and degraded areas, a process which safeguards and expands their carbon stores. As wetland sediments and debris build up, stores of carbon do too, and rewetted peatland areas have the potential to significantly contribute to emissions reductions. For example, rewetting just 3% of agricultural land in the EU could reduce agriculture-derived GHG emissions by up to 25%.[6]

Wider benefits of peatland rewetting include increased biodiversity and the regeneration of vegetation and freshwater filtration systems, with new water sources and changes in soil composition attracting diverse animal species. This process can be driven by human action: by blocking drains or deculverting rivers; or left to animals like beavers to re-engineer the landscape: building dams and ditches which allow watercourses to naturally expand across floodplains.

But economic and productive benefits also play a role in meaningful land management change. Rewetted peatlands can generate income for farming communities and help to decarbonise the construction sector, supporting the delivery of housing. Using the Sernitzmoor, an area of spring bog peatland in the north-east of Brandenburg as a study area, this report examines how sustainable building material production through paludiculture can be accommodated on rewetted peatlands.

In 2021, the German federal government set a target to rewet 250,000 ha of peatland by 2030. Brandenburg is well placed to contribute to this target. With 93% of its wetlands drained, large-scale rewetting projects in the state could substantially reduce Germany's GHG emissions and increase its carbon stores. At the same time, Germany will require 2.9 million additional dwellings by 2025[7], meaning that paludiculture cultivation for construction materials has the potential to alleviate a deepening housing crisis. This report explores how reed, grasses and other paludiculture crops can be cultivated in the Brandenburg region to replace intensive agriculture practices and economically benefit farmers who own and work the land. The report also examines how such an industry could support housebuilding and address a significant housing demand in the Berlin-Brandenburg region.

Material Cultures have been working with Bauhaus Earth and local manufacturers, farmers and conservationists including the toMOORow Initiative and Greifswald Mire Centre to understand the material applications for these crops and how the supply chain for paludiculture construction materials can be supported to scale up and directly benefit from the means of production. While an emerging paludiculture-based construction industry exists in Brandenburg, as evidenced by farms like NaturwiesenHeu, there is latent potential for locally-owned and regionally distributed paludiculture products.

By understanding the material properties of wetland reeds and grasses, it is clear that a wealth of construction material products can be derived from paludiculture farming. These species' natural properties allow them to be used in a range of applications, including for structure, insulation and lining; with products ranging from structural straw boards, batt insulation, compressed boards and timber.

At Sernitzmoor, we have used an 80 hectare (ha) site as a study area, exploring reed cultivation and its capacity to be processed into materials for house building. Quantifying the amount of reed

6 Greifswald Moor Centrum. 2021. "Opportunities for Peatlands and Paludiculture in the EU Common Agricultural Policy." GMC Briefing Papers.

7 Bundesinstitut Fur Bau-, Stadt- und Raumforschung. 2011. "Neubaunachfrage in Deutschland bis 2025." Retrieved June 2023, from https://www.bbsr.bund.de/BBSR/DE/forschung/fachbeitraege/wohnen-immobilien/wohnungsmarktprognose/Archiv/Neubaunachfrage/neubaunachfrage.html

material required for a detached home's entire insulation and roofing needs, our research shows that this 80 ha site could supply enough material for the construction of 60 houses, with the essential inclusion of a 10% (8 ha) biodiversity buffer. This means that a single house can be built from reed harvested in roughly a hectare of land. Although this land analysis has been made based on the construction of a detached home, it is clear that more efficient typologies, such as apartment blocks would lead to materials savings, meaning that the same site could provide for even more homes. If this model was expanded across the 250,000 ha of peatlands the German government intends to rewet by 2030, there is potential for this land to supply construction materials for up to 1875,000 homes per year while actively sequestering carbon in both soil and building.

Several barriers to the expansion of a paludiculture construction products sector exist. Challenges include limited consumer demand, cultural misconceptions about paludiculture products, limited manufacturing capacity and untested routes for capital investment in such initiatives. However, a range of actions could overcome these hurdles including state subsidies, the scaling of manufacture and the development of cooperative business models which ensure value generated by final products is retained by producers. By supporting the development of landowner-led paludiculture and high-value construction products, an economic incentive to expand rewetting initiatives is created. By testing and scaling this model internationally, this land use strategy has significant potential not only to deliver homes and decarbonise the construction sector but also to sequester carbon and restore wildlife, addressing the polycrisis of climate, biodiversity and housing.

50,000 ha

The German government needs to rewet 50,000 ha of peatland a year to meet carbon neutrality by 2030

1,000 ha

The German government is only achieving 1,000 ha of rewetting at the moment

75%

of Brandenburg's peatlands are used for agriculture

25%

Reduction in emissions by rewetting only 3% of the EU's land drained for agriculture

1.2 ha

of cultivated reed

1 ⌂

insulated with rigid reed panels + clad with thatch roof

250,000

hectares available area for cultivation

187,500 ⌂

If 10% of the rewetted peatland left fallow for biodiversity gain

1 Peatlands

1.1 Global Peatlands today

Peatlands are land-based wetland ecosystems. Their waterlogged conditions prevent organic material from fully decomposing[8], and the rate of decomposition for organic matter within peatland soil is slower than the production of new material, meaning that peat layers accumulate within an ecosystem over time.

There are around 500 million hectares of peatland globally, found in various forms in almost every country on Earth. Peatlands occur in every climatic zone, with temperate peatlands present in northern latitudes, such as those in Germany, and tropical peatlands existing below rainforests or within mangrove forests.

Despite covering just 4% of the planet's land surface, peatlands store twice the amount of carbon as all of the forests on earth[9]. But despite peatlands' properties as a powerful carbon store, containing up to a third of the world's soil carbon[10], around 50 million hectares, or 12%, of carbon storing peatlands have been lost, an area half the size of Egypt[11].

Peatlands are being degraded globally in several ways and for several reasons. Major causes include drainage for agriculture and forestry, erosion through livestock overgrazing, mining for fuel and horticulture and pollution caused by human activity. This drainage and degradation has led to the microbial oxidation of peatland soils, forming a significant source of greenhouse gas (GHG) emissions.

8 International Peatland Soceity. "What are Peatlands?" Retrieved June 2023, from https://peatlands.org/peatlands/what-are-peatlands/

9 "Peatlands are lands with a naturally accumulated peat layer at their surface" - R. Biancalani and A. Avagyan. 2014. Towards climate-responsible peatlands management. p.vii. Rome: FAO

10 "total carbon stored in them globally estimated to be in the range of 450,000 to 650,000 megatons" - UNEP. 2022. "Global Peatland's Assessment: The State of the World's Peatlands."

11 UNEP. 2022."Global Assessment Reveals Huge Potential of Peatlands as a Climate Solution." Retrieved June 2023, from "https://www.unep.org/news-and-stories/press-release/global-assessment-reveals-huge-potential-peatlands-climate-solution#:~:text=Around%2050%20million%20hectares%20of,human%2Dinduced%20GHG%20emissions%20annually.

With approximately 16% of global peatlands having been drained, degraded areas have turned from a net sink for these emissions to a net source. Damaged peatlands are now estimated to emit 1.9 gigatonnes of CO_2 equivalent every year[12], or around 4% of all anthropogenic emissions, a higher amount than the entire global shipping industry.

If greenhouse gas emissions from drained and degraded peatlands continue at this level unabated, they will consume 12% of the remaining global emissions budget to keep global warming below +2 °C and 41% of the remaining emissions budget to keep global warming below +1.5 °C.

For decades we have cultivated a perception of our global soils as infinite resources, from which harvest after harvest can be extracted with little consequence, but this has been a fiction. Beyond the release of emissions, the degradation of our global peatlands pose further risks to both land, ecology and our own survival.

The drainage of peatlands has been largely led by the agriculture sector, with drained areas providing new farmland and access to fertile, nutrient-rich peat soil. Soil erosion, drought and forest fire are direct consequences of wetland drainage and many peatlands drained for agriculture have subsequently been abandoned through a combination of progressive soil degradation and decreasing productivity.

Drained peatlands also disrupt the critical role wetlands play in the water cycle: filtering water, slowing and distributing water flow across landscapes and mitigating the impact of floods. In fact, the drainage of peatland can also lead to the lowering

12 "Because of drainage, organic soils are currently the third-largest emitter of GHGs in the Agriculture, Forestry and Land Use (AFOLU) sector; they emit almost one gigaton of CO_2 equivalent (CO_2-eq), which represents 10 percent of the total AFOLU emissions. High GHG emissions are particularly evident when oil palm and pulpwood production are carried out under deep drainage and high temperature on tropical peatlands" - R. Biancalani and A. Avagyan. 2014. Towards climate-responsible peatlands management. p.vii. Rome: FAO

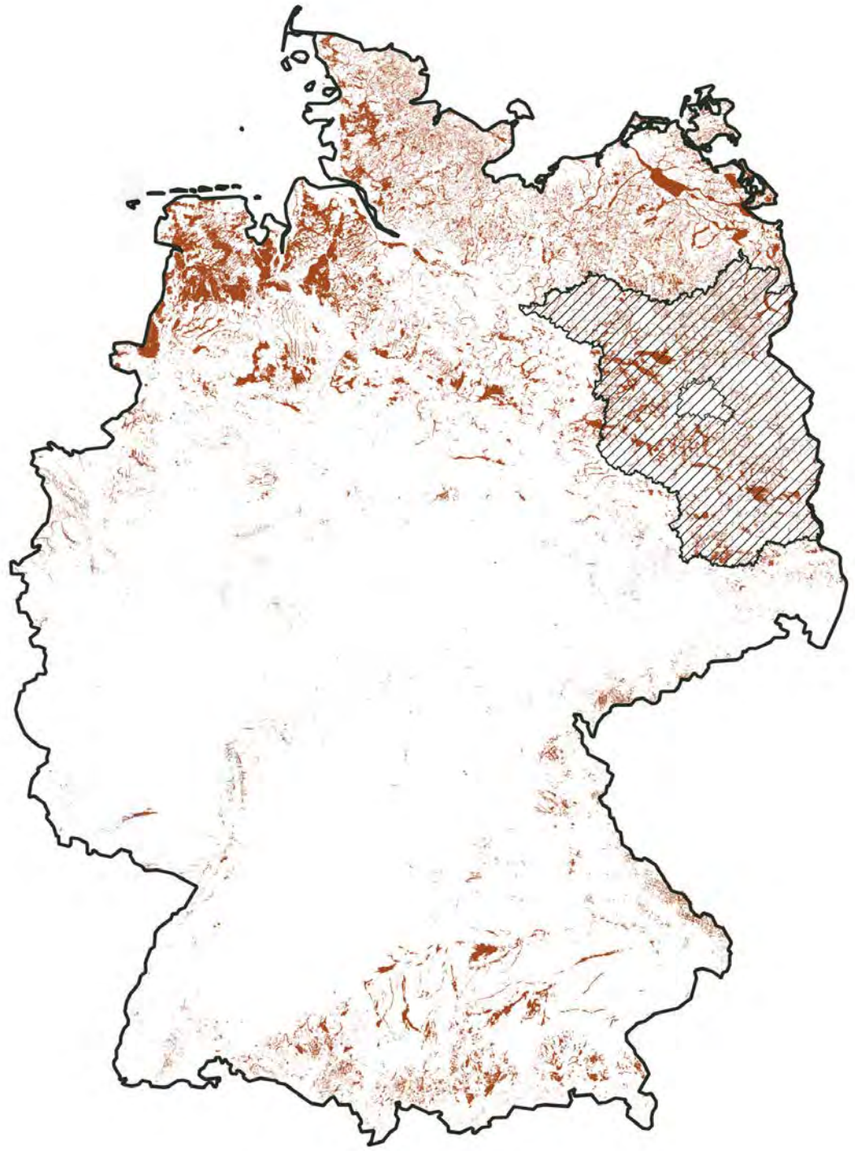


Fig 1.1: Peatland distribution in Germany with Brandenburg state highlighted in the North-East

of land surface heights, making regions more susceptible to harmful coastal and fluvial flooding. Aquatic ecosystems often rely on the water filtration and distribution properties of peatlands and the drainage of these regions can lead to the collapse of ecosystems and loss of biodiverse habitats and endangered species, for which both our wellbeing and survival depend.

The protection and restoration of global peatlands is an integral part of the challenge to prevent climate breakdown and ecological collapse, and these actions are particularly important in the context of Europe, which has experienced the largest proportional degradation of peatlands of any continent in the world.

1.2 Germany

12% of global peatlands can be found in Europe, covering an estimated 59 million hectares, with higher densities in northern lowlands, highlands and coastal areas and sparser distribution in steppe and broadleaved forest regions. Large-scale drainage of peatlands for economic activity began in Europe over a thousand years ago and over time has led to a dramatic reduction in both the size and quality of these ecosystems: 50% of European peatlands are now classed as degraded.

Agriculture has often been the principal reason for drainage, with drained peatland leading to a range of economic uses; from food, animal fodder and timber production to peat extraction for fuel. The rise of extractive practices in peatland areas, led to the erosion and displacement of traditional practices such as food and medicinal plant foraging, hunting and reed harvesting.

As a result, peatland regions have been transformed into areas of plantation forest, arable and livestock farming, construction and mineral mining areas. Bisected by settlements, railways and roads, naturally occurring ecosystems and drainage patterns have fragmented and in some places collapsed entirely.

1.8m ha

of peatland in Germany

93%

of German peatlands have been drained

50,000 ha

The German government needs to rewet 50,000 ha of peatland a year to meet carbon neutrality by 2030

1,000 ha

Brandenburg's government aims to deliver 70,000 ha of reforested land

The European Red List of Habitats lists thirteen peatland habitats, three of which are classed as endangered and one as critically endangered. Despite this, only 20% of the continent's peatlands are designated as protected areas.

These historical practices have led to a significant loss of biodiversity, reductions in both the quality and supply of water and the catastrophic release of stored carbon through greenhouse gas emissions. In fact, Europe has experienced the largest proportional degradation of peatlands of any continent in the world and is the second largest greenhouse gas emitter from drained peatlands globally, releasing close to 600 megatonnes (Mt) of CO_2e annually.

Despite their use as arable and pasture land, drained peatlands account for a fraction of Europe's farmland, representing just 3% of the EU's agricultural land. By contrast, rewetting these areas would sequester up to 25% of the EU's total agriculture greenhouse gas emissions.

Of the 59 million hectares of European peatland, 1.8 million hectares are in Germany. Of this figure, 90% (or 1.5 million hectares) of German peatlands have been drained[13]. These areas produce 43.3 Mt of CO_2e emissions every year. Looking at this another way, although only 5 percent of Germany's farmland is on drained peatland areas, these areas release 50 percent of the country's soil-related greenhouse gas emissions and more than 7 percent of Germany's total emissions[14]. To put this into perspective: drained peatlands emit 25 times as much greenhouse gas as Germany's domestic air traffic[15].

In 2021, the German state and federal governments jointly set a target to reduce annual CO_2e emissions from drained peatlands by 5 million tonnes by 2030. To meet this target, the country must 'rewet' 250,000 hectares of land by 2030 (or 50,000 ha per year), a total land area equal to that of Luxembourg.

However, an average of only 2,000 ha of peatland have been rewetted each year over the past 20 years. If this rate remains unchanged, a total of 18,000 ha will have been rewetted by 2030, a shortfall of 92.8% compared to the government's target. With a national rewetting shortfall of 48,000 hectares per year, without a substantial acceleration in peatland rewetting, Germany will fail to meet its own target by a considerable margin.

The country's annual rewetting target of 50,000 ha remains a substantial hurdle to Germany becoming climate neutral by 2045. However, developing localised rewetting initiatives which provide economic land use benefits in tandem with ecological ones could see rewetting levels exceed that figure[16].

1.3 Brandenburg

In the late 19th century, the wetlands surrounding the Sernitz River in the federal state of Brandenburg, eastern Germany were drained to access fertile peat soils for agricultural use. In this former wetland context, Material Cultures and Bauhaus Earth are exploring the interplay and relationship between landscape conservation and construction material production. 15% (264,000 ha) of Germany's peatlands are located in Brandenburg, of which 93% (247,000 ha)[17] have been drained for agricultural purposes. This level of peat soil drainage has resulted in significant greenhouse gas emissions from these soils. According to a 2020 study by Greifswalder Moor Centrum 2020, around 6.2 million tonnes of CO_2 equivalents are released from

13 Interview with Jan Peters, Fabian Frucht and Dr Nina Seifert of the Michael Succow Stitfung, with Material Cultures and Bauhaus Earth conducted on Thursday 16th March 2023
14 Clean Energy Wire. 2019. "Moorland Restoration Could Play Much Bigger Role in German Emissions Reduction." Retrieved June, 2023, from https://www.cleanenergywire.org/news/moorland-restoration-could-play-much-bigger-role-german-emmissions-reduction
15 UNEP. 2022. "Global Peatland's Assessment: The State of the World's Peatlands."
16 Interview with Claudia Bühler and Dr Tim Eckhardt of the Michael Otto Environmental Foundation, with Material Cultures and Bauhaus Earth conducted on Tuesday 21st March 2023
17 Ministerium für Landwirtschaft,Umwelt und Klimaschutz, 2023. Moorschutzprogramm Brandenburg

drained peat soils in Brandenburg each year, a level of emissions greater than from the state's entire transport sector[18].

With the German federal government's annual target of restoring 50,000 ha of wetland currently falling short (with around 2,000 ha restored annually) Brandenburg is well-placed to contribute to this national target, and on May 14th 2020, the state parliament passed a resolution to "Develop and implement a moor protection program"[19]. The resolution includes a 10-point program and targets for 2025 to restore and regenerate peatlands and to protect the carbon stored within. Accompanying plans to restore the nearly 260,000 ha of peatland in the state, Brandenburg's government aims to deliver 70,000 ha of reforested land and 60,000 ha of space for solar plants and wind energy[20] to further the state's climate goals.

However, this land use strategy has been criticised by the state's farming communities. Under the plan, Brandeburg's farmers could lose around a third of their farmable area, with Landesbauernverband Brandenburg, the state farmers association sharply criticising the environment ministry's vision. The association estimates that close to 400,000 hectares of agricultural land will be lost by 2045, and while the state government is planning to offer 1 billion euros in compensation to farmers by 2030, local unions estimate the figure required is closer to 4 billion euros.

Regenerative land practices offer the opportunity to create wealth for existing landholders through the development of carbon-sequestering industries, whilst contributing to the state government's climate neutral ambition to rehabilitate Brandenburg's moor soils. Options include biomass, which can be

18 Agrarheute. 2023. "Wiedervernässung: Streit ums Moor in Brandenburg." Retrieved June, 2023, from https://www.agrarheute.com/pflanze/wiedervernaessung-streit-ums-moor-brandenburg-604776#:~:text=Die%20Landesregierung%20Brandenburgs%20hat%20ein,Hektar%20liegen%20in%20dem%20Bundesland.
19 Brandenburg state parliament printed matter 7/1122-B
20 Agrarheute. 2023. "Ausschreibungen für Solar- und Windenergieanlagen: Nachfrage gestiegen." Retrieved June, 2023, from https://www.agrarheute.com/energie/strom/ausschreibungen-fuer-solar-windenergieanlagen-nachfrage-gestiegen-604089

15%
of Germany's peatlands are located in Brandenburg

6,200,000
Tonnes of CO_2 equivalents are released from drained peat soils in Brandenburg each year

75%
of Brandenburg's peatlands are used for agriculture

25%
Reduction in emissions by rewetting only 3% of land drained for agriculture

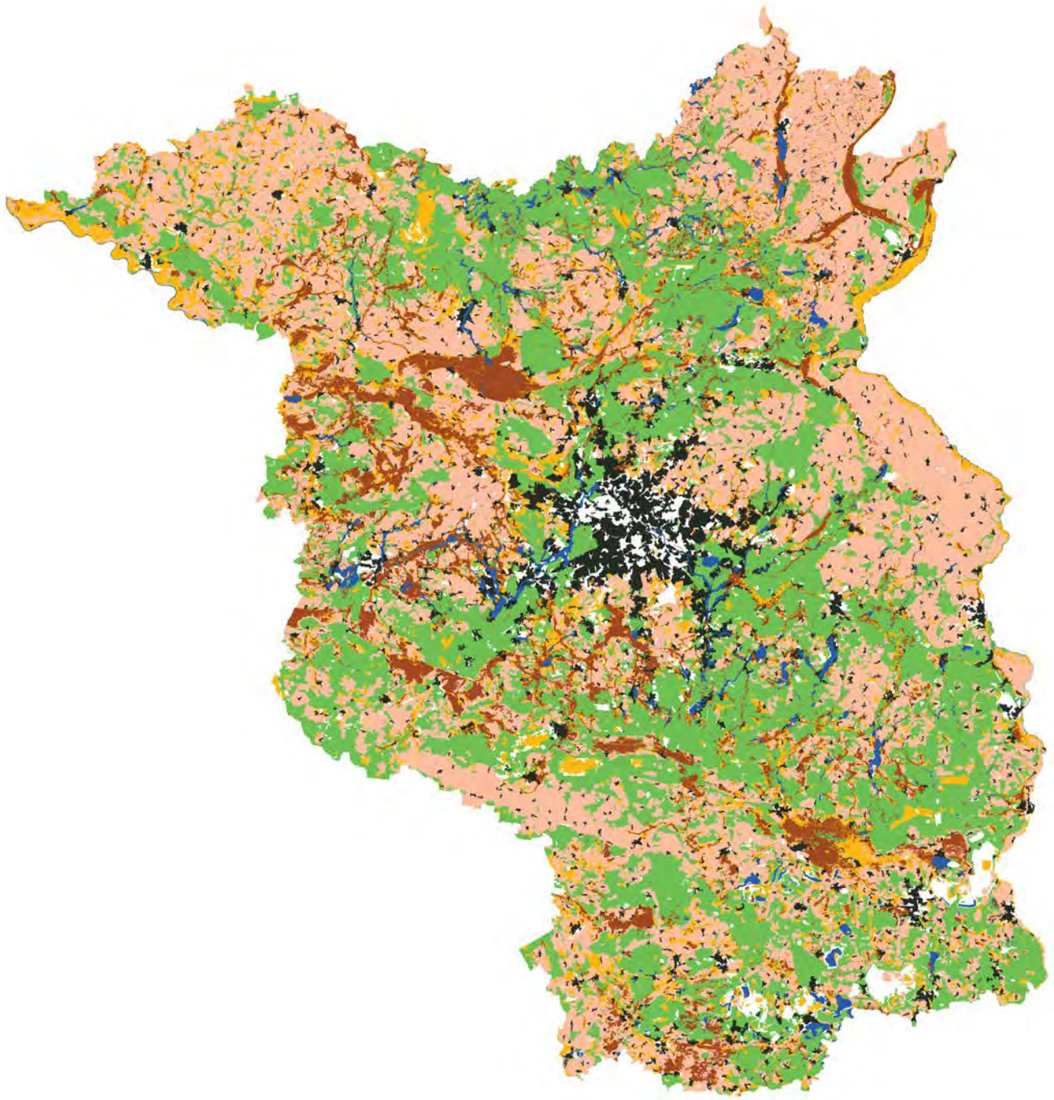
grown on wet moor soils and processed into insulation materials, used for animal bedding or planting soil, while another possibility is the rearing of water buffalos on peatland sites.

Several projects in the Sernitz region are already beginning to re-saturate areas of existing farmland. This includes the toMOORow Initiative, a partnership between the Michael Otto Environmental Foundation and the Michael Succow Foundation, partners in the Greifswald Mire Centre.

The Sernitz region also presents an opportunity to address Germany's housing crisis, with the country needing an extra 2.9 million apartments by 2025. Areas of Brandenburg surrounding Berlin have the highest rate of housing demand in the country, with more than 40 new apartments needed per 10,000 inhabitants[21]. Local housing demand in the state can be addressed through local building material supply and manufacture.

Wetland projects along the Sernitz will be pilots for peatland restoration across Germany, and could serve as templates for restoring floodplains and wetlands across the globe. The scale of this landscape restoration work asks us to reconsider our relationship to both land and water and how we make use of both to create wealth and livelihoods for local people.

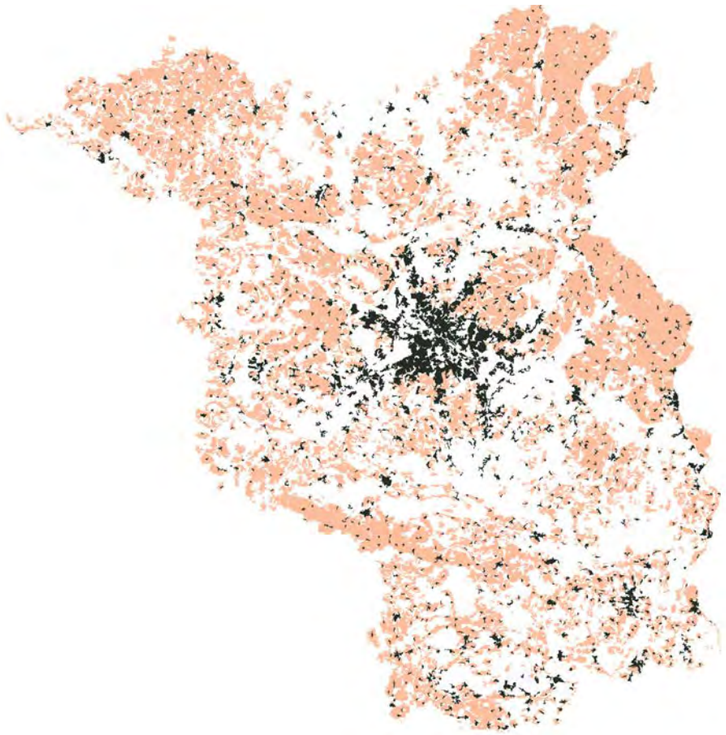
21 Bundesinstitut Fur Bau-, Stadt- und Raumforschung. 2011. "Neubaunachfrage in Deutschland bis 2025." Retrieved June 2023, from https://www.bbsr.bund.de/BBSR/DE/forschung/fachbeitraege/wohnen-immobilien/wohnungsmarktprognose/Archiv/Neubaunachfrage/neubaunachfrage.html



Arable
Grassland and Pasture
Woodland
Peatland
Water Bodies
Settlement

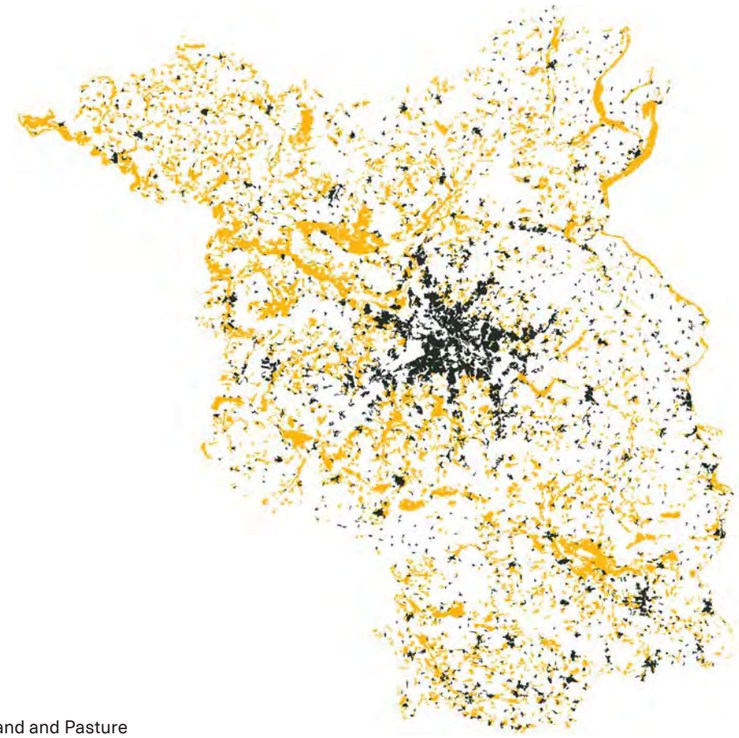
Fig 1.2: Land use classifications in Brandenburg show settlement is concentrated towards Berlin in the centre of the state. Many of the state's peatlands have been drained for agriculture and pasture as shown overleaf on page 26-27

Source: EU Copernicus Land Monitoring Service; Geoportal.de



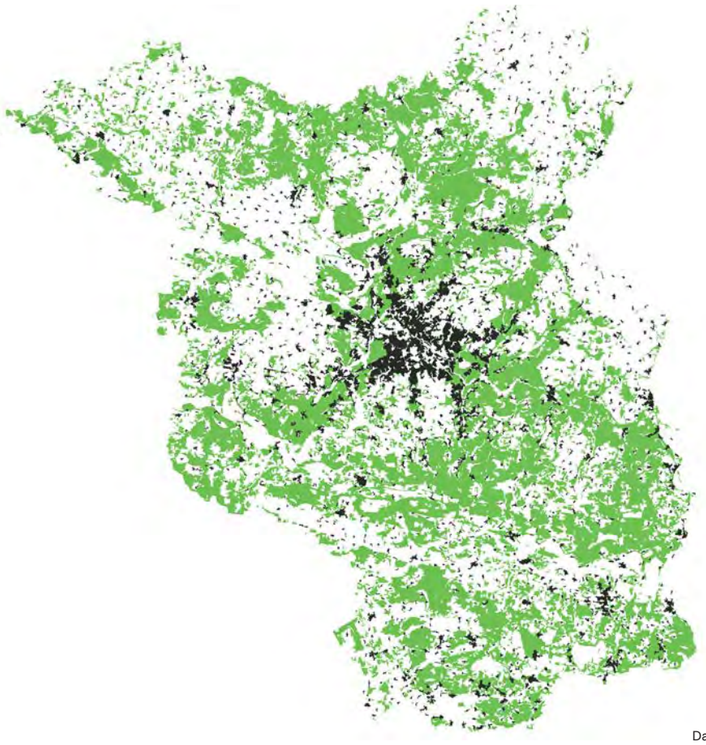
Arable
Settlement

Data: EU Copernicus Land Monitoring Service



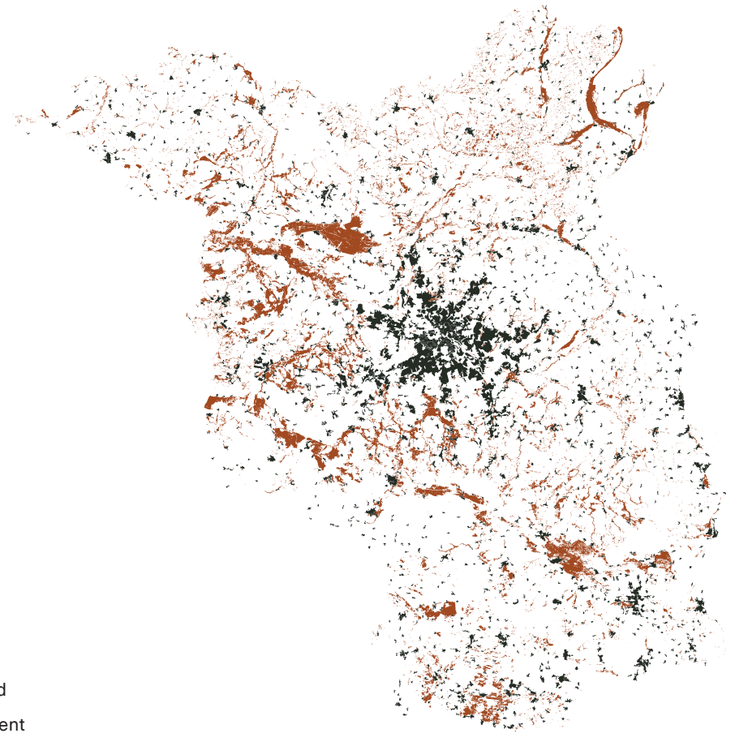
Grassland and Pasture
Settlement

Data: EU Copernicus Land Monitoring Service



Woodland
Settlement

Data: EU Copernicus Land Monitoring Service



Peatland
Settlement

Source: Geoportal.de

2 Paludiculture

Economic and productive benefits can together play a role in meaningful land management change, as demonstrated by the regenerative and sustainable wetland farming practices that can be applied to peatland landscapes.

2.1 What is paludiculture?

Paludiculture is the practice of biomass cultivation in wet conditions, on peatlands. It can be implemented on drained peatlands by rewetting and raising the water level.[22] It's considered to be a responsible management option for peatland management.[23] as the biomass from wet and rewetted peatlands can be produced under conditions which maintain the peat body, sustain its ecosystems and may facilitate carbon sequestration. In addition to the production of agricultural commodities like food, feed, fibre and fuel, paludiculture can also generate other raw materials for a variety of purposes, including industrial biochemistry. [24]

As well as reducing greenhouse gas emissions rapidly, paludiculture can also maintain income for farmers and others who make their livelihoods from peatlands today. Paludiculture has significant potential, particularly on degraded peatlands, to deliver social, economic and carbon reduction objectives. Although the opportunity costs of switching to paludiculture can be high on sites that are currently used for profitable land use, such as horticulture and dairy farming, new markets are developing for wetland species crops and additional income (through natural capital and ecosystem services payments) may make paludiculture not just a viable option but a desirable one.[25]
For paludiculture to be economically sustainable it is anticipated that the materials it produces need to be high value. Biomass from paludiculture can almost never compete with dryland alternatives[26], and as such the initiation of programmes to develop products that exploit the unique properties of wetland plants across different industries, such as the construction industry, is a key element in encouraging sustainable peatland restoration.

22 Interview with Jan Peters, Fabian Frucht and Dr Nina Seifert with Material Cultures and Bauhaus Earth conducted on Thursday 16th March 2023
23 R. Biancalani and A. Avagyan. 2014. Towards climate-responsible peatlands management. p.viii. Rome: FAO
24 R. Biancalani and A. Avagyan. 2014. Towards climate-responsible peatlands management. p.viii. Rome: FAO
25 UNEP. 2022. "Global Peatland's Assessment: The State of the World's Peatlands."
26 R. Ziegler, W. Wichtmann, S. Abel, R. Kemp, M. Simard and H. Joosten. 2021. "Wet Peatland Utilisation for Climate Protection – An International Survey of Paludiculture Innovation." Cleaner Engineering and Technology 5: 100305

Fig 2.1: Paludiculture biomass harvested at NaturwiesenHeu and baled into hay

2.2 Cultivating wetland crops

Paludiculture materials are those derived from cultivated wetlands. Humans have cultivated wetlands for centuries. In Germany and Northern Europe, in the temperate or boreal wetlands, paludiculture feedstocks include a wide variety of plants which play important roles in the ecosystems of the wetland.

When a drained peatland site is being rewetted it can take a couple years before the first harvest of paludiculture biomass. An important component in the establishment of peatlands are sphagnum mosses, a genus of approximately 380 accepted species that are habitat manipulators. The differential growth and decay rates among Sphagnum species in different microhabitats are important mechanisms behind the formation and maintenance of mire structures such as hummocks, hollows, and pools. As a critical species to peatlands, in some peatland restoration projects mosses or moss fragments are introduced alongside processes of managed rewetting.

Sphagnum mosses grow slowly compared to other vegetative wetland crops, at a rate of about one millimetre per year. Methane, produced in the anoxic, water saturated conditions of the peat soil, is usually oxidised by the sphagnum layer of the mire system but certain wetland specific plants have venting holes through which the methane is able to bypass the moss. In the initial establishment phase where the vegetation grows at a faster pace than the moss, a peak in methane emissions is therefore often observed, and can even be higher than that of the drained sites. However, the methane emissions of intact and preserved peatlands are low in comparison to drained sites as the landscape establishes a balance. Preliminary observation is therefore important when undertaking rewetting actions but in general, as an observed phenomenon in the rewetting process, this initial spike in methane is not considered a permanent long term problem.[27] As sphagnum grows so slowly (one millimetre a year) there are farms in the Netherlands, but also in Germany, where the sphagnum is grown to then be applied to the landscape as the mire's initial moss layer.

The most recognized of the paludiculture species with direct relationships to the construction industry are:

- Common Reed (Phragmites australis)
- Reed Canary Grass (Phalaris arundinacea)
- Water Sedge (Carex aquatilis)
- Cattail (Typha)
- Alder (Alnus)
- Willow (Salix)

27 Interview with Claudia Bühler and Dr Tim Eckhardt of the Michael Otto Environmental Foundation, with Material Cultures and Bauhaus Earth conducted on Tuesday 21st March 2023

Common Reed (Phragmites australis) Poaceae Family

Ecology

A variety of the highly productive Poaceae grass family, the Common Reed is one of the world's most widely grown wetland plants found in most climatic regions except for Antarctica. Reed is a pioneer species, meaning it can establish itself in habitats where it is not already growing, and its rhizomes, (the perennial part of the plant) are able to initiate new reed stands when carried and deposited by moving water such as in fen and coastal habitats. Reed is monodominant, propagating quickly and growing to several metres in height.[28] Reed can withstand flooding and drought conditions provided they occur seasonally rather than irregular extreme weather events.[29]

Characteristics

Grasses in the poaceae family characteristically have a hollow, jointed stem that is round in cross section, with Common Reed in particular flowering in late-summer and seeds with grains.[30]

Harvested reed is classified as short (90cm-1.2m), medium (1.2-1.7m) and long (1.7m-2m)[31]. Left unmanaged, the accumulation of dead litter can dry out the reed beds, thus facilitating natural succession of the wetland into woodland as scrub (i.e willow) and young trees (i.e alder) establish. Regular cutting of reed and clearance of the material from the reed bed is therefore an important way of managing wetland habitats for wildlife. However it is also crucial in the cultivation of straight reed culms (important for use in thatching) which would otherwise become 'dog legged' if new growth has to find its way under and through older reed stands.[32]

The high concentration of silica in the reed provides several advantageous properties including increased durability and structural flexibility, whilst reducing the desirability of the biomass to insects and other pests.[33] It also reduces the ability of the reed fibre to absorb moisture and so often reed is used in combination with a hydrophilic material like clay, which can draw away moisture collected in the reed.[34]

Uses

Harvesting in summer when it has a higher nutrient content allows it to be used as fodder for animals with an assurance that the harvest will not coincide with the nesting season of wetland bird species. However reed has its lowest moisture content in winter, which lends itself as raw material for crafts and construction materials.[35]

Evidence of thatching with straw is found as early as 740-400 BCE in Germany and when thatching with reed straw in particular, a roof can last for 50-100 years. However its longevity is greatly affected by artificial fertilisers which can reduce its lifespan to 30 years.[36]

Reed biomass can also be processed, such as in the twentieth century when it was popular for pulp and paper production, or more recently as a renewable energy source which importantly, is unlikely to compete with food production.[37] Artificial reedbeds utilise common reed as water treatment systems.

● See: Rigid Reed Panel (Section 3.2, page 67)

28 J.F. Köbbing, N. Thevs and S. Zerbe. 2013. "The Utilisation of Reed (Phragmites australis): A Review." Mires and Peat Volume 13: 1-14
29 S.M. Haslam. 2009. "The Reed." British Reed Growers Association
30 H. Lahring. 2003. "Water and Wetland Plants of the Prairie Provinces."Canadian Plains Research Center
31 British Reed Growers' Association. "Buying and Selling Reed: A description of reed qualities"
32 Thatch Advice Centre. "Water Reed." Retrieved June, 2023, from https://www.thatchadvicecentre.co.uk/thatch-information/thatching-materials/water-reed
33 A. Almusaed and A. Almssad. 2015. "Building materials in eco-energy houses from Iraq and Iran." Case Studies in Construction Materials 2: 42-54
34 S. Neumann and P. Kullmann. "Anwendung Hiss Reet Platte"
35 J.F. Köbbing, N. Thevs and S. Zerbe. 2013. "The Utilisation of Reed (Phragmites australis): A Review." Mires and Peat Volume 13: 1-14
36 B. Berge. 2015. The Ecology of Building Materials. London: Routledge.
37 J.F. Köbbing, N. Thevs and S. Zerbe. 2013. "The Utilisation of Reed (Phragmites australis): A Review." Mires and Peat Volume 13: 1-14

Fig 1.2: Mature Common Reed growing in Brandenburg's Sernitzmoor

Reed Canary Grass (Phalaris arundinacea) Poaceae Family

Ecology

Reed canary grass is a highly productive, clonal variety within the Poaceae grass family, native to Europe, Asia and North America. The grass is well adapted to wetlands with rhizomes that are able to withstand anoxic conditions, however it is also considered to be drought tolerant and is able to grow in dry soils of shaded wooded areas. It grows quickly, with seeds that do not require dormancy prior to germinating and spreads easily, especially along waterways and ditches which help with its seed distribution. It has even been known to follow the water runoff from agricultural and urban sites[38]. For these reasons, it is often considered to be a highly invasive species and is known to develop monocultural stands.

Characteristics

Grasses in the poaceae family characteristically have a hollow, jointed stem that is round in cross section, with Reed Canary Grass in particular flowering in mid-summer and seeds with grains.[39] It is a highly variable, perennial species that develops culms of 0.5-2m height. Clusters of flowers branch off from the culm, called panicles which vary from 0.04-0.7m in length.[40] Reed Canary Grass has short rhizomes which grow in a dense manner that can develop sod, the upper layer of soil from which grass can grow. Its ability to grow so densely means other vegetation is eliminated once it has invaded, to the extent that it is capable of inhibiting tree growth such as in floodplain forests.[41] Management techniques to mitigate this invasive quality are costly and environmentally, although 'spring burning' practised on British wetlands cultivating Common Reed to encourage the budding density has been suggested as a control measure.[42] Grass fibres generally have very heterogeneous fibres, especially when compared to the fibre composition of wood pulp, with the quantity of fine fibres and the length of fibres generally, varying across the length of the culm. There is a high content of silica, potassium and chlorine in RCG which can be a challenge to some processing systems such as the recovery of chemicals used to manufacture pulp.[43] The composition of these components vary during the development stage of the plant, therefore harvest time can be utilised to minimise the contents of such elements. RCG is also considered to be absorbent.[44]

Uses

Reed canary grass is often cultivated for pasture, hay or silage. Legume mixtures are recommended especially for hay or silage production. Perennial grasses generally have a high energy ratio (the amount of energy stored in the biomass is more than required to cultivate, transport and process it into biofuel), however the high ash content in reed canary grass remains a challenge.[45] For burning in biomass power stations, the grass can be turned into bricks or pellets. Short fibre pulp can be made from Reed Canary Grass that can be utilised in the production of fine paper and applied as the top layer of a board. It has also been reported that Reed Canary Grass contains the compound DMT (N,N-Dimethyltryptamine) that is known to have psychoactive effects. The phenomenon of "Phalaris Staggers", a temporary syndrome affecting coordination in grazing animals ingesting RGC in large quantities, is speculated by some to be associated with this presence of DMT.[46]

38 R.R. Sharitz. 2014. Ecology of Freshwater and Estuarine Wetlands. University Of California Press.
39 H. Lahring. 2003. "Water and Wetland Plants of the Prairie Provinces."Canadian Plains Research Center
40 S.I. Apfelbaum and C.E. Sams. 1987. "Ecology and Control of Reed Canary Grass (Phalaris arundinacea L.)." Natural Areas Journal 7
41 Iowa State University Extension and Outreach Natural Resource Stewardship. "Reed Canary Grass Invasive Species Profile." Retrieved June, 2023, from https://naturalresources.extension.iastate.edu/encyclopedia/reed-canary-grass-invasive-species-profile
42 S.I. Apfelbaum and C.E. Sams. 1987. "Ecology and Control of Reed Canary Grass (Phalaris arundinacea L.)." Natural Areas Journal 7
43 B. Andersson and E. Lindvall. 2016. "Use of biomass from Reed Canary Grass (Phalaris arundinacea) as raw material for production of paper pulp and fuel"
44 ibid
45 C. Wrobel, B. E. Coulman and D. L. Smith. 2009. "The potential use of reed canarygrass (Phalaris arundinacea L.) as a biofuel crop." Acta Agriculturae Scandinavica Section BSoil and Plant Science 59: 118
46 Entheology. 2002. "Phalaris arundinacea – Reed Canary Grass." Retrieved June, 2023, from https://entheology.com/plants/phalaris-arundinacea-red-canary-grass/

Fig 1.3: *Phalaris Arundinacea,* a species of Reed Canary Grass

Sedge (Carex)
Cyperaceae Family

Ecology

Sedges are a genus of over 2000 species, most of which are found in moist habitats such as bogs, edges of freshwater and saltwater marshes, and dominate in wet mountain meadows and other high-elevation habitats. They are significant, often dominant components, of many types of wetlands throughout the world, both tropical and temperate. They are thus of crucial importance to primary productivity. Their fruits, and sometimes their shoots and tubers, often produced in quantity, are important food for many aquatic and amphibious animals. Large stands of sedges are also critical as cover for many wetland animals.[47]

Characteristics

Sedges in the cyperaceae family characteristically have a solid, un-jointed stem. Sedges produce a dry one seeded fruit to seed, called an achene and flowers in summer.[48] The grass grows and is harvested in similar conditions to water reed, with the added advantage that it can be cropped all year round.[49]

The distinctive triangular cross section of sedge grows in an elongated leaf with sharp, serrated edges that necessitate gloves when handling the material. Some sedges, like the Greater Tussock Sedge (Carex Paniculata) grow in tufts up to 1.5m in height and 1m across in colonies of 20 to 30 plants in close proximity. The dark spaces in between are ideal shelter habitat for smaller aquatic species like water voles.[50]

Greater Tussock Sedge requires a particular habitat to grow and therefore can be used as an indicator of ecosystem health. [51]

Uses

Sedges are an important food source within the wetland ecosystem, and can be harvested to use as animal fodder. The elongated blades are also good at slowing the movement of water, and although the impact is less researched, the plant is capable of filtering pollutants from the water. Different species can be used in combination to maximise the benefits of this impact on a wetland site.

In the Middle Ages sedge was considered a valuable crop, with records showing many fenland communities in Britain forbidding its sale outside the village monitored by 'Keeper of the Sedges' and punished with fines.
Sedge can be used for roof ridges in thatching. Although it is very durable, generally lasting longer than conventional straw and often only requiring resparring rather than rethatching, its sharp edges make it complex to work with as a thatching material.[52]

There is a long tradition within some indigenous communities of North America utilising the leaves and/or rootstocks for weaving, matting, cordage or medicinal purposes.

● See: Grass batt insulation (Section 3.2, page 65)

47 Petaluma Wetland Alliance. 2021. "Sedges in Our Wetlands." Retrieved June 2023, from https://petalumawetlands.org/wetlands-life/sedges-in-our-wetlands/#:~:text=Sedges%20are%20often%20found%20in,world%2C%20both%20tropical%20and%20temperate.
48 H. Lahring. 2003. "Water and Wetland Plants of the Prairie Provinces."Canadian Plains Research Center
49 Thatching Info.com. "Water Reed & Sedge Grass." Retrieved June, 2023, from https://thatchinginfo.com/water-reed/
50 P. Brown. 2018. "Species watch: greater tussock-sedge – safe haven and playground." Retrieved June, 2023, from https://www.theguardian.com/environment/2018/jan/23/specieswatch-greater-tussock-sedge-safe-haven-and-playground
51 Wild Flower Web. "Greater Tussock Sedge." Retrieved June, 2023, from http://www.wildflowerweb.co.uk/plant/1546/greater-tussock-sedge
52 Thatch Advice Centre. "Less well known Thatching Materials." Retrieved June, 2023, from https://www.thatchadvicecentre.co.uk/thatch-information/thatching-materials/less-well-known-thatching-materials

Fig 1.4: *Carex paniculata*, colloquially known as Greater Tussock Sedge

Cattail (Typha)
Typhaceae Family

Ecology

Cattail is a genus of about 30 species of tall reedy marsh plants largely distributed in the northern hemisphere, where it is found in a variety of wetland habitats. It is a perennial plant that tends to be a monodominant stand for several reasons; the plants grow fast (approx. 15 t/ha of dry plant mass), particularly in areas where the water has a high nutrient concentration due to over-fertilization from conventional agricultural methods[53] and develops a dense canopy as it matures, that can exclude other plants. It also releases a substance that is toxic to its own seedlings to prevent germination in existing colonies it has already established.[54] Cattail prefers consistently water saturated environments until at least mid summer, flowering in late-summer. Therefore one means of control is to intentionally fluctuate water levels including periods of drought to create an infertile environment for cattail.

Characteristics

Cattail has long, large alternating leaves that grow to over a 1m tall along the plant in pear-like form with leaves that are much stronger and larger at the bottom, getting smaller moving up the stem. This means, unlike Common Reed that has a fairly consistent structure over its length, most of cattail's biomass is concentrated towards the bottom of the plant where machinery would ideally harvest, posing a challenge for conventional machinery which gets easily clogged by the concentration of biomass.[55]

The cattail leaves are very strong due to their fibre reinforced structure stabilised by a soft open cell spongy supporting tissue which gives the biomass combined insulative and structural properties that lends itself to use in construction materials. The hollow chamber-like structure of the stem and leaves supports floattion and transportation of oxygen to its dense creeping network of rhizomes which can be found underground or float just under surface water level.

The plant's distinctive sausage-shaped seed head, or spadix, typically sits above the foliage and holds a dense mass of tiny hair-like flowers which are easily carried in the wind once the plant matures. These abundant wind-dispersed achenes enable Cattail to successfully and easily colonise areas of newly exposed wetland soil which can make it difficult to limit its spread in habitat.

Uses

Cattail can be used as thermal insulation in buildings as an organic alternative to conventional insulating materials such as glass wool or stone wool. It can also be used to make paper, fibres for textiles and biofuel.

Its long leaves can be used whole for weaving mats, baskets or as part of shelter, or the leaves' long fibres lend itself to making emergency cordage. The cattail-fluff from the mature spikes also has varied uses; insulation for textiles (blankets, clothing etc), tinder for fire, or as a fine fibre mixed into clay plaster to achieve fine finishes.

Many parts of the plant are edible to humans; the inner core at the base of the leaves can be eaten raw, the roots pounded into a corn-starch-like flour rich in starch and proteins, and the young spikes can be boiled to eat like sweetcorn cob.[56] Evidence of preserved starch grains on grinding stones suggests they were already eaten in Europe 30,000 years ago. The rhizomes are fed on by wetland mammals species such as beavers and muskrats as well as birds like Canada Geese. There is some evidence that harvesting cattail removes nutrients from the wetland that would otherwise return via the decomposition of decaying plant matter.[57]

53 Fraunhofer. "Building material made from typha." Retrieved June, 2023, from https://www.ibp.fraunhofer.de/en/projects-references/building-material-typha.html
54 H. Lahring. 2003. "Water and Wetland Plants of the Prairie Provinces."Canadian Plains Research Center
55 Interview with Anke Nordt by Material Cultures and Bauhaus Earth on Friday 10th March 2023
56 H. Lahring. 2003. "Water and Wetland Plants of the Prairie Provinces."Canadian Plains Research Center
57 N. Cicek, S. Lambert, H.D. Venema, K.R. Snelgrove, E.L. Bibeau, R. Grosshans. 2006. "Nutrient removal and bio-energy production from Netley-Libau Marsh at Lake Winnipeg through annual biomass harvesting." Biomass and Bioenergy Volume 30, Issue 6: 529-536

Fig 1.5: Detail of cattail's with its distinctive seed head

Alder (Alnus)
Betulaceae Family

Ecology

Alder trees are a key feature of alluvial woodlands[58] which occur on floodplains in a range of situations from islands in river channels to low-lying wetlands along river corridors. It's commonly used in flood mitigation. It grows quickly and is short lived, with a life span of approximately 60 years. Alder fixes nitrogen in its root nodules, giving it the ability to grow in poor soils. Although existing stands of Alder can be preserved on peatlands, it is difficult to introduce new alder trees onto wetlands due to German legislation aimed to prevent interference with the wetland ecology – new alder trees introduce oxygen into the soil which accelerates the process of soil mineralisation.[59]

Characteristics

It's one of the softest woods in the hardwood family, just harder than pine and beech – both commonly cultivated species in Brandenburg. Alder can be successfully coppiced. Individual stems are optimally harvested at between 17 and 27 years, and grow between 20 and 35 m tall with a diameter between 250-860mm when mature.

Alder has low bending strength, low stiffness, low resistance to shock, but medium crushing strength.[60] Consequently it cannot be used in building construction as structural timber. Alder is a closed or fine grained wood similar to cherry, birch and maple. Alder has a light uniform colour of both heartwood and sapwood which make it easy to form, fasten and finish. When the bark is cut or damaged, the heartwood is initially a deep orange-red colour, subsequently drying to a pale timber.

More work needs to be undertaken to understand the potential of Alder. Anecdotally it is said to have similar properties to Ash and coincidentally Alder is being planted as an ash replacement because it grows in a similar way with a similar canopy cover to Ash. Generally it is quite ambivalent about where it grows.[61]

Uses

As timber, alder is typically used for solid wood and veneer applications like doors, furniture, joinery, mouldings and turnings. Its homogeneous growth ring structure lends itself to the production of plywood and it is commonly chipped to use in chipboard along with species like pine, spruce, beech, poplar and birch.

As Alder doesn't rot quickly when exposed to alternately wet and dry conditions, it was historically used in mill clogs and some canal lock works. Provided it is fully submerged, it is highly durable – the old towns of Amsterdam and Venice rest partly on alder poles alongside the more well known oak poles.

Alder can be acetylated for use in the manufacture of a product sold as Accoya, enabling its use externally for cladding, decking and joinery.[62]

● See: Glulam and dowel laminated timber (Section 3.2, page 63)

58 Alluvial wetlands are dynamic and successional woods dominated by alder Alnus Glutinosa and willow Salix.
59 Interview with Sebastian Petri by Material Cultures and-Bauhaus Earth on Friday 10th March 2023
60 Association of Scottish Hardwood Sawmillers. "Alder." Retrieved June, 2023, from https://www.ashs.co.uk/index.php?option=com_content&view=article&id=89&Itemid=559#:~:text=Strength%20%26%20Structure&text=Density%20Similar%20to%20lime%2C%20530,metre%20at%2012%25%20moisture%20content.
61 Jez Ralph, director of Evolving Forests, is working on a project testing the British common Aldus Glutinosa
62 Accoya Alder. "Lumber Grading and Dimensions Specifications." Retrieved June 2023, from https://pdf.archiexpo.com/pdf/accsys-technologies/accoya-alder-lumber-grading-dimensions-specifications/69612-177249.html

Fig 1.6: Detail of an Alder tree branch with leaves, cones and a pair of catkins

Willow (Salix)
Salicaceae Family

Ecology

Willow is also a key alluvial woodland species, adapted to continuously moist environments to the extent that they readily suffer from water-shortage and loss of leaves if the water-table is too low[63]. Willow is often an early species in the succession of land into woodland. It is ecologically a very important species supporting a large number of insect species most of which cause little damage to the tree or shrub itself, whilst the ground cover provided by willow's density provides an ideal habitat for a diversity of invertebrates such as earthworms, web spinning spiders, beetles and butterflies. This in turn leads to an increase in the number of small mammals and birds.

Characteristics

Its 350 species are varied – ranging from tall deciduous trees, like Black Willow, that can be harvested for lumber to smaller shrubs that flower with attractive catkins in the spring like Grey Willow. Its fibrous roots are effective at filtering diffuse pollutants and are able to stabilise river banks.

Willow is usually coppiced, producing multiple stems of between 6–15cm diameters. It is a commonly utilised Short Rotation Crop (SRC) for soil remediation and biomass energy production. The rotation cycle depends on species and growing conditions, and ranges from 3–5 years. When harvested its stems are long and bendy, this flexibility allows willows to be used for applications involving weaving. Coppicing also increases biomass, minimises wind damage, and the coppicing management cycle also provides a range of different types of habitats within its short rotation which caters to many different species of bird.

63 Nicholson, B.E. and Clapham, A.R. 1979. The Oxford Book of Trees. Newton Abbot: Readers Union.

Uses

The history of the human use of willow predates stone-age technology. Salicylic acid, a key ingredient in aspirin, is also found in willow bark extract and had been utilised for pain relief for over two centuries before the aspirin was available commercially.[64]

As flexible smaller diameter stems, willow represented the most common structural component of wattle/daub construction for shelter and fencing. It was also the primary material for basket production and straight willow branches were used for arrow shafts and fish traps. In the Netherlands hand woven coppice 'fascine mattresses' were used to reinforce dykes and harbours. The constructions covered an area the size of a football pitch, and was weighed down with stones; many of these constructions from the 17th century are still in place today.[65] Willow is now often cultivated as short rotation coppice, from which wood chips are readily harvested for biomass energy plants. It is also planted for habitat and ecosystem purposes, such as to stabilise river banks with its fibrous roots, and live Willow stakes have been evidenced to manage and contain the growth of Reed Canary Grass, a monodominant species, in wetland restoration projects.[66] The possibilities of willow compost as a substitute for peat compost are also being investigated.[67]

64 Y.A Kuzovkina and M.F.Quigley. 2005. "Willows Beyond Wetlands: Uses of Salix L. Species for Environmental Projects." Water, Air and Soil Pollution 162, 183–204.

65 Low Tech Magazine. "Fascine Mattresses: Basketry Gone Wild." Retrieved June, 2023, from https://solar.lowtechmagazine.com/2021/11/fascine-mattresses-basketry-gone-wild/#:~:text=Around%20the%2017th%20century%2C%20the,canals%2C%20estuaries%2C%20and%20rivers.

66 K. Dae Kim, K. Ewing, and D. E. Giblin. 2006. "Controlling Phalaris arundinacea (reed canarygrass) with live willow stakes: A density-dependent response." Ecological Engineering 27: 219 – 227

67 Compost from willow biomass (Salix viminalis L.) as a horticultural substrate alternative to peat in the production of vegetable transplants

Fig 1.7: A grey willow shrub from afar with Cardaminopsis Arenosa flowers in the foregound

Sphagnum moss: As a critical species to peatlands, in some peatland restoration projects mosses or moss fragments are introduced alongside processes of managed rewetting.

Cattail: This can be harvested and chopped to make thermal insulation in buildings as an organic alternative to conventional insulating materials such as glass wool or stone wool

Seedwool: These delicate fibres collected from the heads of cattail and reed can be added to clay plaster to create a fine rendered finish

Grasses: Reed Canary Grass and Sedge can be harvested and baled in a hetergenous mix to make insulation products for buildings

3 Construction

Discussions with and visits to manufacturers in the region indicate that while an emerging paludiculture-based construction industry exists in Brandenburg, there is latent potential for locally-owned and regionally distributed paludiculture products.

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1 The yard of ROBETA Holz sawmill
2 Unmilled logs at ROBETA Holz sawmill
3 1:1 mock up of reed matts bound with jute instead of wire at Hanffaser Uckermark
4 Baled wetland grasses
5 1:1 straw and lime mock up at Hanffaser Uckermark
6 Detail of a 1:1 straw mock up lined with a reed mat at Hanffaser Uckermark

I

II

III

IV

V

VI

VII

I Detail of mineral bound strawboard
II Detail of a wetland fibre board tests manufactured by Zelfo
III Detail of weathered mineral bound straw board
IV Detail of wire bound reed panels
V Detail of dried paludiculture biomass
VI Detail of dried reed chips
VII Mineral bound strawboards rendered onto a jute render mesh

3.1 State of the industry

The biobased construction industry in Brandenburg today is predominantly timber based – 36.6% the region is forested[68], of which 70% is cultivated pine[69]. Significant work mapping the well established timber supply chain in Brandenburg was carried out by Wirtschaftsförderung Brandenburg in their 2017 report 'The Forestry and Lumber Industry in the Capital Region Berlin-Brandenburg'. Low levels of annual rainfall and regular periods of drought in recent years has deepend concerns about the health of the forest region in Brandenburg, in which the extensive pine forests have suffered considerably on the now dry, sandy soils. It is anticipated that over the coming decades the water-hungry, fast growing softwood woodlands might need to be replaced with cultivated hardwood trees, which are more drought and heat tolerant. This potential for a near-term timber supply shortage could have significant implications for the region's economy, in which 33,000 people are employed by the forestry and wood sector[70]. Within the broader palette of biobased construction materials, paludiculture materials are also not directly comparable to most timber based products, which are currently well accepted in the construction sector. Structural timber, but also timber based lining boards and insulation products are relatively commonly in use.

A well established hemp product manufacturer, Hanffaser Uckermark is based within the Brandenburg region. Founded in 1997, Hanffaser Uckermark supplies the construction industry with an extremely wide array of hemp, clay and biobased construction materials, manufactured using locally sourced hemp.

Some paludiculture manufacturing has also begun within, and around, Brandenburg. Zelfo, a manufacturer of paludiculture processing machinery, is established in Joachimsthal and Schwedt in Brandenburg. Zelfo's machinery produces heat-pressed paludiculture based sheet materials, using different wetland grasses which are defibrillated and bound together in a heat press. These materials are extremely robust, and have the potential to be tested and certified as MDF and OSB substitutes. The other established paludiculture construction material manufacturers are either based outside of Brandenburg, in other regions of Germany, such as Typha Technik Naturbaustoffe, or in other parts of Europe, as with Gramitherm, a grass insulation batt manufacturer who utilise paludiculture grasses in their manufacturing. There is extraordinary potential for these businesses to establish regional processing and manufacturing centres within Brandenburg, working hand-in-hand with the wetland farmers and ecologists. One example of this to come is a soon to be established cooperative business run by four wetland farmers in the region, who are purchasing compressed straw board manufacturing machinery from istraw, in order to establish their own production line for a Brandenburg paludiculture strawboard. This is an exciting development which would establish a high value product stream for the local farmers in and around the wetlands.

68 European Commission. 2022. "Factsheet on 2014-2020 Rural Development Programme for the German Länder Berlin and Brandenburg."
69 Wirtschaftsförderung Brandenburg. 2021. "The Forestry and Lumber Industry in the Capital Region Berlin-Brandenburg"
70 ibid

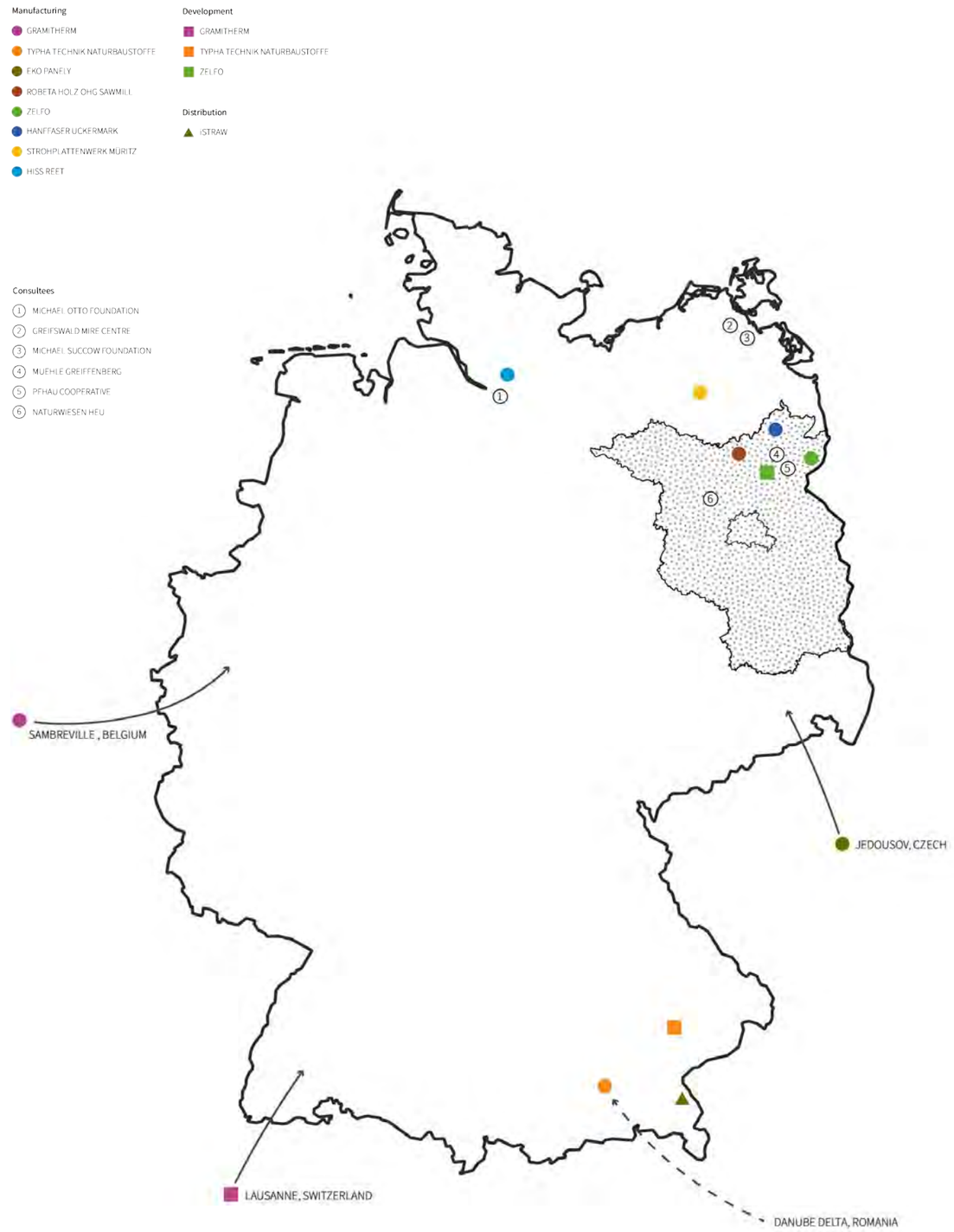


Fig 3.1: Map highlighting the location and distribution of manufacturers and processers consulted

3.2 Material applications of paludiculture biomass

From the ground up, all buildings are predominantly made up of three constituent parts: the structure of the building—its bones, which might be a lightweight frame or a series of load-bearing walls; the insulation; which gives the building envelope its thermal performance; and the lining materials; which form the internal surfaces of habitable rooms. As they constitute the bulk of the construction material used in new build projects or the retrofit of existing buildings, this appraisal of applications for paludiculture biomass in the construction sector focuses on the following three material applications:

A Structure
B Insulation
C Lining

Conventional construction often relies on a structure built of precast concrete block; petrochemical derived insulation materials like rigid foam insulation; and rooms lined with plasterboard made of gypsum. Paludiculture provides an opportunity to breakaway from this material palette that perpetuates ecologically damaging practices in construction. Paludiculture construction materials have inherent properties that make them well suited to be developed in building materials: wetland crops are adapted to live in a wet environment, as such the materials made with them have a degree of innate mould and moisture resistance. Their plant stems are often particularly strong as they grow resistance to waves and tides, which can be much stronger than winds.[71]

A The structure of biobased construction systems typically utilises a load bearing material such as timber, clay, stone or earth. Crops cultivated in paludiculture systems provide substantial quantities of above ground biomass from wet meadow land and these grasses generally lend themselves less to structural uses. The structural capacity of alder, a hardwood species common to wet woodlands, is currently under researched.

B Insulation in construction, whether applied inside a wall cavity, internally or externally, limits the transition of heat through the building envelope. Consequently, it reduces the energy required to operate a building. Biobased wall and roof insulation materials can be made from renewable sources such as animal fibres (e.g. sheeps wool) and plant fibres (e.g. hemp, straw, woodfibre or flax). These materials can replace petrochemical-derived building insulation without any loss of thermal performance. However, in order to achieve comparative U-Values,[72] some of these materials necessitate thicker walls and structural systems. Biomass from paludiculture lends itself to application as insulation in both a regulatory and technical sense. Developing insulation products for the market is, in regulatory terms, simpler than developing a structural product or component. The structure of paludiculture biomass itself is also naturally insulating due to its vent-like holes and hollow tube structures.

C Lining boards are used as part of floor, wall or roof build-ups. Conventional examples include plasterboard, Oriented Strand Board (OSB) and sarking boards. Lining boards are conventionally used on the internal side of a wall build up. They act as a render-carrying board, onto which the plaster can be skimmed and then painted. This report focuses on select products that would be viable alternatives to plasterboard, the most commonly used product. Gypsum based plasterboard is drawn from finite mineral resources and is energy intensive to recycle. It can also generate large amounts of waste. It is currently estimated that 300,000 tonnes of plasterboard per year are wasted as a result of a combination of over-ordering by contractors, incorrect specifications, material damage on site, and off-cuts arising during construction.[73]

71 Interview with Anke Nordt by Material Cultures and Bauhaus Earth on Friday 10th March 2023

72 The U-value is a measure of heat transmission through the building envelope.

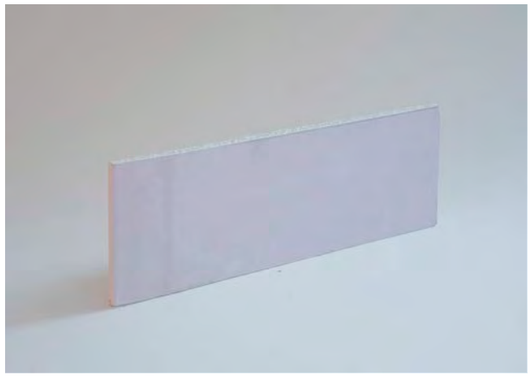
73 The Roy Hatfield Group of Companies. "Plasterboard Recycling." Retrieved June 2023, from https://royhatfield.com/what-we-do/recycling/

A Conventional Structure
Concrete Block

A Biobased Structure
Structural Timber

B Conventional Insulation
Polyisocyanurate (PIR) Board

B Biobased Insulation
Rigid reed panel



C Conventional Lining
Plasterboard

C Biobased Lining
Compressed strawboard

A Structure

Typhaboard
Manufactured by Typha Technik Naturbaustoffe

Reels (Lehmwickel) – a timber and earth flooring system
Manufactured by Restaurierungen Schneevoigt

Alder timber
Harvested within Brandenburg

Alder timber
Processed and milled in Berlin

1 Structural Sheathing Board

Sheathing boards refer to those that are fixed to a primary structure; they can aid with both structural racking as well as air-tightness. The structural sheathing board market today is dominated by Oriented Strand Board (OSB), a timber composite board product, made from randomly oriented pieces of wood 'strands'. Composite boards like OSB are bound together under heat and pressure with adhesives and glues in manufacturing processes that are known to use formaldehyde and other volatile organic compounds (VOCs). VOCs continue to be widely used in construction and building products like paints, varnishes, adhesives, solvents and flame retardants despite the fact that the presence of VOCs affecting indoor air quality and the associated health risks in residential and public buildings are well reported.[74] It has been estimated that composite boards also require about 15 times more energy to produce compared to rough sawn timber.[75] An alternative is yet to be available on the market, but a number of significant developments have been made in the production of what is known as Typhaboard, using the cattail plant, and a compressed strawboard, which has yet to be tested for its racking strength but can be used today as a complete partition wall system.

1.1 Typhaboard: The insulative and structural properties of cattail biomass (See Section 2.2, page 30) lends itself to use in construction materials. Based in Schönau in Bavaria, Typha Technik Naturbaustoffe have developed Typhaboard, a structural sheathing board made from magnesite-bound cattail chips. Although yet to be formally certified, its structural capacity was demonstrated in a pavilion entirely constructed with Typhaboard at the Milan Expo 2015. It also has excellent insulating properties and therefore has significant potential to combine both structural and thermal performance in a single product once certification is acquired. The Greifswald Moor Centrum cites that mass production of the product has been prevented by "a scarcity of cattail cultivation and obstacles in the agricultural subsidy policy".[76] Presently most of the typha utilised in these products have been imported from the Danube Delta in Eastern Europe due to the lack of resources available from Germany.[77]

1.2 Structural Straw Board: Compressed straw boards are heat and pressure pressed, paper-backed straw panels produced without the need for glues due to the lignin inherent within the straw. There is a German distributor of compressed straw boards called iStraw, partnered with the Czechoslovakian manufacturer Eko Panely. Although iStraw currently only distributes drywall boards that do not have a structural application, director Marcel Burgstaller is developing an OSB alternative called OSSB (Organic Structural Straw Board) which utilises a biodegradable organic protein glue with straw biomass to create a structural sheathing board.[78] These could be made with wetland grasses, including canary grass (See: Section 6, NaturwiesenHeu, page 126).

2 Structural Timber

2.1 Glulam and dowel laminated beams: Alder is a tree commonly found in wetlands, although it's known to have low bending strength, low stiffness, and a medium crushing strength, it has potential to be used in engineered timber products. In the UK today it is being planted as an ash replacement in places where ash dieback disease has spread, as alder grows in a similar way and has similar canopy structure and cover. Evolving Forests, a group of specialist timber and forestry consultants in the UK will be carrying out product development on kiln dried alder in the latter part of 2023, to develop a glue laminated alder beam product made with small, 27mm lamella alder sections.

74 S. Vardoulakis, E. Giagloglou, S.Steinle, A. Davis, A.Sleeuwenhoek, S.K.Galea, K.Dixon and O.J.Crawford. 2020. "Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review." International Journal of Environmental Research and Public Health V17(8972), p. 2-24.

75 C.Harris, P. Borer. 2005. The Whole House Book: Ecological Building Design and Materials. Second Edition, Centre for Alternative Technology

76 Typha Technik Naturbaustoffe. "Insulation Board by Typha Technik." Retrieved June 2023, from https://www.moorwissen.de/files/doc/publikationen/Baumaterialien/englisch/Typhatechnik%20D%C3%A4mmplatte_englisch_layout_EUKI_mm.pdf

77 Interview with Anke Nordt by Material Cultures and Bauhaus Earth on Friday 10th March 2023

78 Interview with Marcel Burgstaller by Material Cultures and Bauhaus Earth on Friday 10th March 2023

B Insulation

Unprocessed meadow grass
Harvested by Sebastian Petri

Processed meadow grass insulation
Manufactured by Gramitherm

Paper back straw board
Distributed by istraw

Typha sandwich panel
Manufactured by ATB

1 Loose Fill Fibre

Loose-fill insulation consists of loosely placed or compacted fibres for thermal and acoustic protection, often placed within a timber frame construction or used to fill in hard to reach cavities. The advantage of using loosefill insulation is its simplicity – the harvested wetland grass or plant fibres can be crushed and placed within the wall cavities. Adequate testing and certification is needed to guarantee thermal performance, and the fibres themselves would need to be enclosed and protected from exposure to spread of flame and damage from pests. The minimal processing, however, involved in the use of loosefill insulation means that the embodied carbon of the materials in use will be significantly lower than the more processed insulation products on the market.

In 2020, a construction demonstrator known as Torsten Galke (Tiny House) project was constructed in Greifswald, Mecklenburg-Vorpommern State, utilised paludiculture biomass including reed, cattail, grasses and alder. The project, a touring demonstrator, showcased how products produced from paludiculture biomass can be incorporated into building systems for example industrially produced batt insulation made from wet meadow grasses were used alongside blow in insulation made from cattail. The cattail was harvested on site by students of the University of Greifswald and processed by a hemp product manufacturer, Hanffaser Uckermark, in the North East of Germany.[79] The u-values and life spans for typical loose fill grass insulation are under researched.

2 Grass Batt Insulation

Batt insulation comes in flat pieces, and it is generally used for thermal and acoustic insulation mainly in internal partitions between studwork, rafters and floor joists as well as sometimes being used as cavity insulation. Business-as-usual insulation is often made of energy intensive fibreglass or mineral wool which is pre-cut into flat pieces. Some batt insulation comes with a foil or paper facing and some comes with no facing.

Rigid and flexible insulation batts can be manufactured from plant fibres, bound together by heat and steam or with additive binders. Some of these fibrous batts are mixed with supplementary materials, such as recycled polyester. This market-ready batt insulation product could replace more energy-intensive materials such as rockwool and polyurethane insulation. This could happen with relative ease as its installation methods and application is consistent with the commonly used alternatives.

2.1 Gramitherm is a biobased batt insulation product produced using a mix of harvested grass and recycled jute fibres. The grass fibres are extracted and separated from the liquid within the plant, which is later used for the production of biogas. The fibres are bound together using heat. Gramitherm, or a grass batt product like it, could be manufactured using wetland grasses such as canary grass, within Brandenburg. In terms of its land-use implications, 1 acre of land will produce 200 m^3 of insulating products, and for every 1kg of insulation panel, the equivalent of 1.5kg of carbon is captured. It has a U-value of 0.041 and it comes in batts of between 45 and 240mm thick. It's estimated to last at least 50 years, and is fully recyclable.

79 Interview with Anke Nordt with Material Cultures and Bauhaus Earth conducted on Friday 10th March 2023

B Insulation

Wire bound reed panel
Manufactured by Hiss Reet

Fibre foam board
Manufactured by Fraunhofer Institut für Holzforschung WKI

3 Compressed strawboard

Compressed straw boards are manufactured by placing straw under intense heat and pressure. This creates a reaction in the natural resins within the straw that binds the materials together. The materials are bound at the edges with paper to create a board material that can be used for a number of applications, such as partitions or lining boards. There is a German distributor of compressed straw boards called iStraw, partnered with the Czechoslovakian manufacturer Eko Panely. The techniques used in the manufacture of Eko Panely's boards are similar to those used to manufacture a strawboard product sold across the globe in the latter part of the 20th century, known as Stramit. Eko Panely's boards come in thicknesses are 40mm and 60mm, and its u-values are 0.099. It's estimated to last up to 100 years, and is fully recyclable. Compressed straw boards could be made with wetland grasses, including canary grass, as well as biomass from reed, typha and sedges. This is being prototyped by istraw (See: Section 6, page 126).

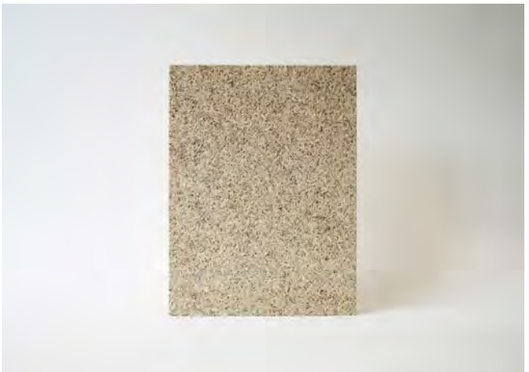
4 Rigid panel insulation

4.1 Reed panel: The Hiss Reet reed insulation panel is both a rigid insulation batt, and a suitable substrate for renders. The hollow spaces within each individual reed spear and air layers between the reed spears provide the Hiss Reet Panel with good performance as a thermal and acoustic insulator. As well as being made of renewable reed, the panels are bound together tightly under pressure with galvanised wire. The panels can be used as interior, exterior or roofing insulation. Today they are manufactured in Bad Oldesloe, Schleswig-Holstein State, using imported yellow turkish reed. Its thicknesses vary between 30 and 120mm and it has a u-value of 0.055.

4.2 Fibre foam board: An innovative new product is a dark green grass foam board insulation which is looking to become an alternative to styrofoam with comparable insulation values but the added advantage of being biodegradable. Developed by agricultural engineers at the Arbeitsgemeinschaft Schwäbisches Donaumoos, the product is in the early stages of development and testing.[80] A sample was commissioned by the MoLaKlim project in the Ostallgäu district in cooperation with ARGE Schwäbisches Donaumoos from meadow clippings. Researchers at the Fraunhofer WKI in Braunschweig have also been involved in the project. However a large timber company has since acquired the patented technology and plans to set up a production line based on wood fibre in northern Germany which has prevented further development of this exciting product utilising moor substrates.

80 BR24. 2023. "Bringen Bauplatten den Moorschutz in Gang?" Retrieved June 2023, from https://www.br.de/nachrichten/wissen/bringen-bauplatten-den-moorschutz-in-gang,Tglq78l

C Lining



Mineralbound strawboard
Manufactured by Strohplattenwerk Müritz

Fibreboard made from 100% wet meadow fibres
Manufactured by Zelfo Technology GmbH

Strawboard
Manufactured by Leibniz-Institut für Agrartechnik und Bioökonomie (ATB)

Clay board
Manufactured by Lehmbaustoffe Schleusner

1 Compressed Boards

1.1 Strawboards: As described in Section 3B insulation, are manufactured by placing straw under intense heat and pressure. By producing them at thinner thicknesses, they can also be used as dry lining boards to clad interior surfaces and used in combination with other insulation materials such as grass batt insulation or loose fill insulation. The boards can be made from paludiculture biomass like reed, typha and sedges.

1.2: Fibreboards: Grass is more heterogeneous as raw material than wood, containing a high percentage of fines, (very short fibres). The amount of fines, as well as the length of the fibres differ in different parts of the plant. The compressed fibreboard machinery manufacturer Zelfo Technology GmbH, based in Joachimsthal, Brandenburg, make use of specialised processing to break down plant fibres at a microscopic level to help them bind together more tightly. Zelfo fibreboards are not bound together using the typical synthetic resin adhesives used in the business-as-usual fibreboard: MDF or Medium Density Fibreboard. The fibreboards are composed of self-binding Engineered Fibres are free of any additional binder and rely solely on hydrogen bonds between fibre. Zelfo machinery produces extremely robust lining boards using grass fibres, such as those derived from paludiculture grasses. These sheet materials which have the potential to be tested for their use in structural applications, such as the webbing of engineered joists.

2 Mineral Bound strawboard

Adhesive or mineral binders are to bind the fibres of sheet materials together, many conventional industry products rely on synthetic adhesives that are often toxic and non-biodegradable. Strohplattenwerk Müritz, a biobased strawboard manufacturer based in Mecklenburg use a mineral binder for their sheet material products. Their 20 and 30mm thick biobased insulating and furniture boards are made using a number of different natural fibres, from hemp and miscanthus to straw and seagrass, bound together with a mineral binder. Their manufacturing technology enables different plant fibres to be substituted into the manufacturing process, subject to consistent supply. Their boards meet DIN standards, and have a U-value of 0.087.

3 Reed substrate board

Interior finishes such as lime, clay and plaster need a surface onto which they can key into when they are applied. Wood wool boards are commonly used as a biobased alternative to plasterboard, however reed was also historically used for the purpose in the form of a reed mat. Reed matts are commercially available from the manufacturer Hiss Reet in 1 or 2m wide rolls or 5-10mm thickness. Additionally, Claytec manufactures a board that has innovated on the reed matt to develop a drywall board. A reed matt (wire bound approximately every 20cm) is compressed with building clay and earth, hemp, perlite and jute fabric, to create a dry clayboard that can be used to clad the interiors of wood and metal structures including inner walls, facing shells, ceiling and roof surfaces. The board meets DIN standards. Its thickness is 20mm and it has a u-value of 0.13.

4 Case Study

Using the Sernitz Torfwiese site within Brandenburg's Sernitz-moor as a case study, this analysis explores the potential of paludiculture practices to deliver climatic, ecological and economic benefits when applied at scale.

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1 Mixed herbacious species growing on the Torfwiese site
2 Reed canary grass
3 Research team on site visit
4 Detail of a willow catkin
5 Willow, Alder and Carex acutiformis growing along a stream
6 Alder trees lining the Sernitz river to the north of the site
7 Common reed
8 Multibole alder trees in a riparian woodland along the Sernitz river

4.1 Sernitz Torfwiese

Located within the Schorfheide-Chorin biosphere reserve near the village of Greiffenberg, the Sernitzmoor is one of Brandenburg's most valued spring bog peatlands[81]. Covering an area of 600 ha, the Sernitzmoor consists of peat substrate layers 11m deep, deposited over 10,000 years through the water supply of underground calcareous springs[82]. The EU LIFE funded Schreiadler project estimates the Sernitzmoor stores between 1 to 1.5 million tons of organic carbon, and there is evidence from widespread lake sediment that it was once a lake after the last ice age.[83] If left intact it would support a habitat of "low-growing, but very species-rich vegetation of brown mosses, sedges, rushes, reeds and occasionally alders."[84] Over the last 200 years the peatland across the moor has been drained for intensive agriculture. Drainage began in the 18th century, with the introduction of trenches and the commencement of peat harvests in the 19th century. The expansion of trenches in the 20th century accelerated drainage of the Sernitzmoor and saw a decline in the region's biodiversity.[85] The drainage process also causes reoxidation of the peat, which had previously been kept in anoxic conditions underwater, resulting in the release of vast quantities of CO_2.

The Sernitzmoor, as a site of ecological significance both regionally and nationally, has become a source of renewed interest concerning how best to rehabilitate the landscape. From 2012 to 2019, around 300 ha of Sernitzmoor peatland was rewetted to restore habitats of rare and endangered bird species under the Schreiadler project[86]. The toMOORow initiative will now pilot rewetting in Sernitzmoor specifically for

81 toMOORow. "The Initiative." Retrieved June 2023, from https://www.tomoorow.org/initiative
82 Life Schreiadler. 2019. "Laienbericht-Schreiadler: Documentation of the EU-LIFE Project 2012-2019"
83 Life Schreiadler. "The Sernitzmoor – One of the Largest Spring Mire in Germany." Retrieved June 2023, from https://www.lifeschreiadler.de/en/project/sernitz/the-sernitz-springmire-complex/
84 Life Schreiadler. 2019. "Laienbericht-Schreiadler: Documentation of the EU-LIFE Project 2012-2019". p.22.
85 Life Schreiadler. "The Sernitzmoor – One of the Largest Spring Mire in Germany." Retrieved June 2023, from https://www.lifeschreiadler.de/en/project/sernitz/the-sernitz-springmire-complex/
86 25% funded by the state of Brandenburg and 75% EU funded as part of the EU LIFE project

Fig 4.1: Aerial image of the Sernitzmoor with the toMOORow site outlined in white

agricultural cultivation through a partnership between the Greifswald Mire Centre (Greifswald Moor Centrum), Succow Foundation (Succow Stiftung) and the Michael Otto Environmental Foundation (Umweltstiftung Michael Otto).

The project will rewet an approximately 80 ha site known as the Sernitz Torfwiese (Fig 4.1), and demonstrate the value chains generated from reed (growing up to 3m tall) and lower sedgegrasses (growing up to 1.5m tall) cultivated using paludiculture. It is expected that the project will achieve a saving of around 1000 T CO_2e per year while also improving the water quality of the Sernitz river, creating habitat for resettled wetland species[87]and support local water retention.

Project partners are very interested in the scalability of the initiative. While the 80 ha of the Sernitz Torfwiese toMOORow site will make a small contribution to the 1.5 million hectares of drained and degraded peatlands in Germany[88], as a pilot it can demonstrate the benefits of both rewetting and paludiculture harvest, evidence that can be used to scale up. The potential for this is clear through the direct collaboration between the foundation and a business partner. The Michael Otto Environmental Foundation is affiliated to the Otto Group, Germany's biggest online retailer, which hopes to use the toMOORow site to find alternative biomass for the 12 million cartons of packaging it uses annually.

The first paludiculture harvest at Sernitz Torfwiese will be in 3 years, following the implementation of the rewetting plan. Each partner in the toMOORow initiative at Sernitz Torfwiese is addressing a different aspect of paludiculture. The Michael Otto Environmental Foundation seeks to use the pilot to generate certification for products that emerge in paludiculture-bio-

87 toMOORow. "The Initiative." Retrieved June 2023, from https://www.tomoorow.org/initiative
88 Interview with Jan Peters, Fabian Frucht and Dr Nina Seifert with Material Cultures and Bauhaus Earth conducted on Thursday 16th March 2023

Fig 4.2: Sedge and Alder trees growing along the bank of a stream passing through the site

mass value chains and advocate for federal policy change. The Succow Foundation aims to support local farmers to establish a cooperative to cultivate the land, and will manage the pilot site including water level monitoring, while the University of Greifswald is focused on the properties of biomass fibres and understanding how they could be processed.

Drainage ditches have historically reduced the water level in both ditches and in the Sernitz valley river. toMOORow's plan for Sernitz Torfwiese is to therefore fill the ditches with peat and to bring the water level of the river to meet the level of the topsoil of the site. This is initially achieved by utilising the retaining boards placed vertically in the ditches to act as small dams to block the passage of water and silt. More significant rewetting will be achieved by backfilling ditches with peat to impede water flow and allow the ground to become fully saturated. The initiative is awaiting regulatory and planning approval before starting, but once approved these measures should only take a few months to enact. Project organisers have estimated that, following acquisition of land and subsequent planning applications, approval will be received next year for rewetting activities and then the transition to a paludiculture wetland will commence, with an additional two years until farmers can start harvesting material.

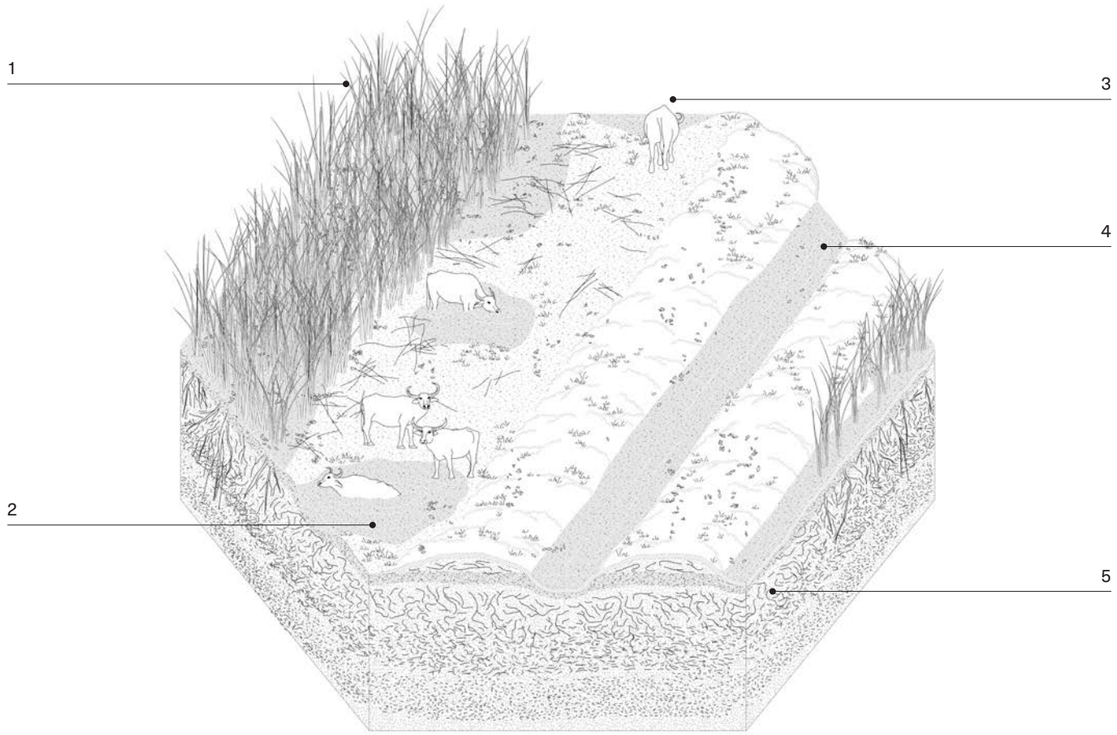
The physical transformation of the Sernitz Torfwiese will deliver tangible ecological benefits alongside the potential for it to act as a catalyst for local social and economic regeneration. The neighbouring village of Greiffenberg was an historic economic hub for the area, with a school serving 1,000 children and a renowned and unique planetarium; but through the gradual loss of industry, the region has been in decline for the latter half of the twentieth century to today.

The wider Angermünde region which the village sits within is well connected however, with high speed rail links to Berlin (currently under renovation) expected to deliver journey times of 45-minutes in the next 2-3 years. Given these links, it's anticipated that the region will increasingly become an attractive commuter town for Berliners looking to relocate, however it is unclear how this dynamic will evolve to benefit the local remaining population. In light of this need for a revitalised local economy in the region, paludiculture provides an opportunity to develop a bioregional economy around construction and manufacturing that supports and celebrates the state's treasured peatlands whilst ensuring economic benefits and income is retained locally.

The first EU LIFE project on the Sernitzmoor emphasised communication with the general public, including the introduction of an educational walking trail around the moor.[89] This has laid the foundation for the acquisition of land at Sernitz Torfwiese for the toMOORow initiative. The toMOORow initiative found that most landowners were happy to sell their farmland, often at higher land values, although some resistance was encountered. In these instances, the project is looking to establish a management contract with the landowners in which they will lease the land in order to proceed with the rewetting and management of the land with paludiculture.

89 Refer to https://www.tourismus-uckermark.de/moorerlebnispfad-greiffenberg/

Wet Meadow



A

B

C

A wetland condition in which the ground is waterlogged partially or totally during the growing season, which prevents the establishment of trees. Some experts consider wet meadows as a type of wetland distinct from marshes.

1 Vegetation: hetergenous mix of vegetation
2 Biodiversity: buffalo create ideal spawning habitat for frogs, toads and newts
3 Vegetation: water buffalo help supress the monodominant reed and allow other low growing species to develop
4 Landscape: drainage ditches are flooded with dams or back filled
5 Landscape: peat subtrates, developed by the roots of the biomass, store CO_2 while

a Exposed peat
b Mixed herbacious species
c Detail of cardaminopsis arenosa flowers

Wet Woodland

D

E

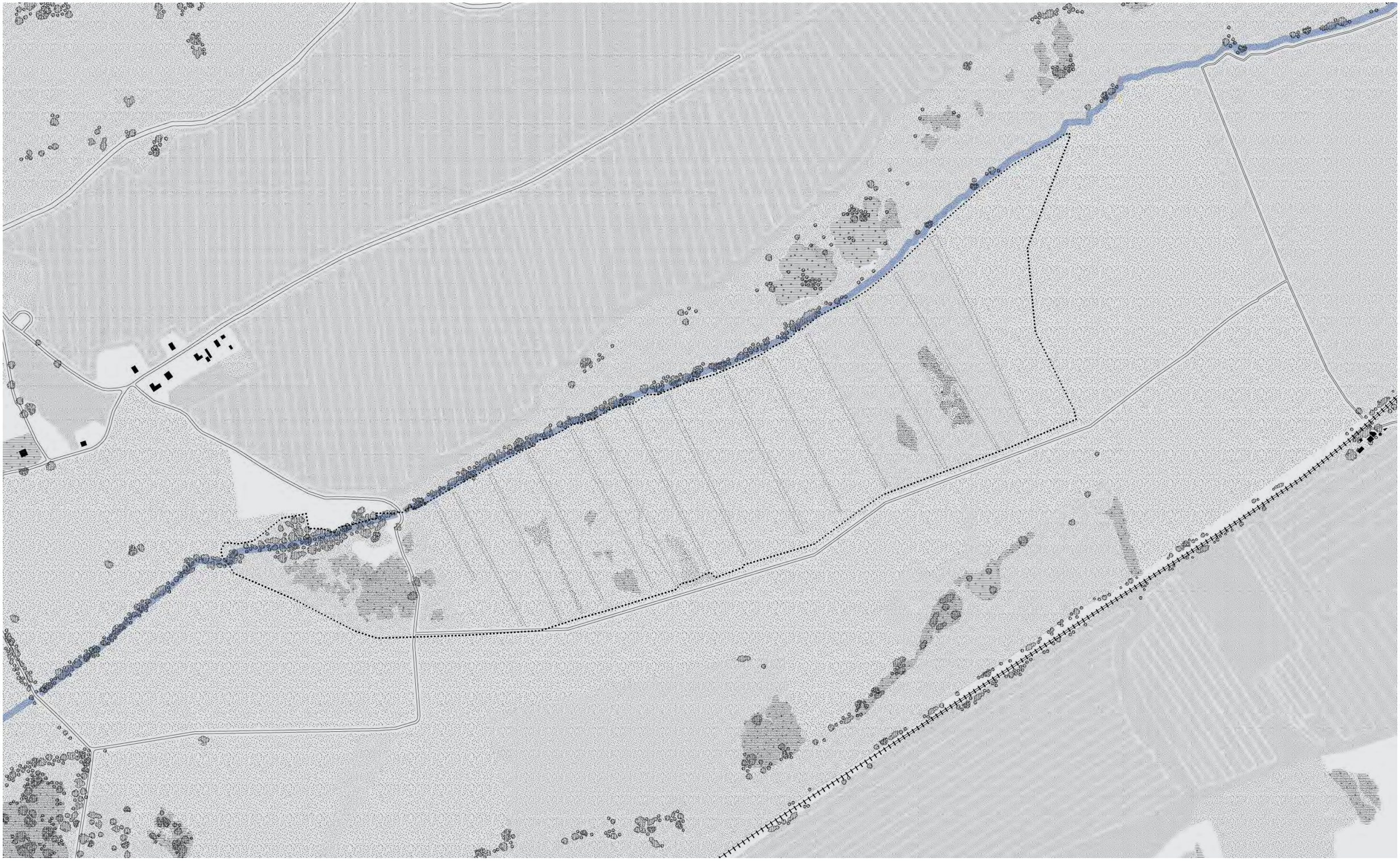
F

Trees growing in wet conditions, including occasional or seasonal scenarios i.e flooding events. Wet woodlands include trees cultivated near bodies of water (lakes, streams, rivers etc), peatlands or wet soil types such as carr.

1 Alder trees
2 River water level raised to surface level
3 Planting
4 Beaver dam

d A multibole alder tree,
e An alder tree felled by beavers
f An Alder with evidence of beaver activity

Torfwiese Sernitz Site Plan



4.2 Business-as-usual vs paludiculture house

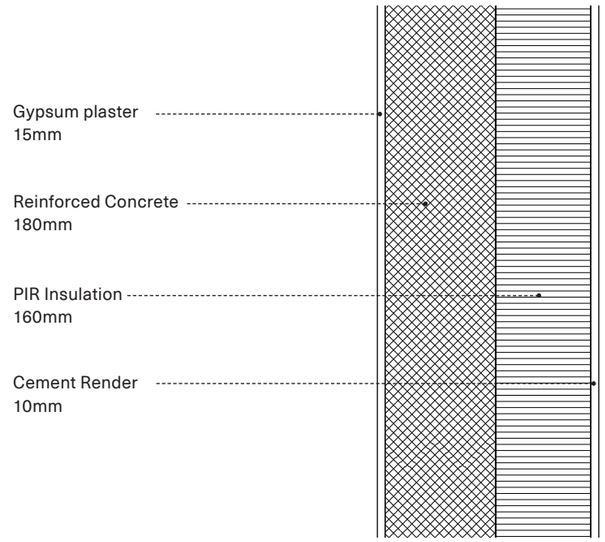
Roughly 40% of German CO_2 emissions are generated by construction-related activities.[90] In light of this, the German federal government has recently released a draft of the 'Handreichung Holzbauinitiative' (timber construction initiative) strategy to achieve climate neutrality by 2030. The strategy focuses on the timber industry to address climate neutrality, with no mention of peatland restoration. Despite this omission, the strategy does identify "Increased use of other renewable resources and materials (e.g. straw, hemp, paludi, mushroom mycelium) in addition to the building material wood"[91] as one of ten priority areas identified for building with wood. However, it remains the case that paludiculture construction materials are significantly undervalued for future construction sector use and carbon sequestration.

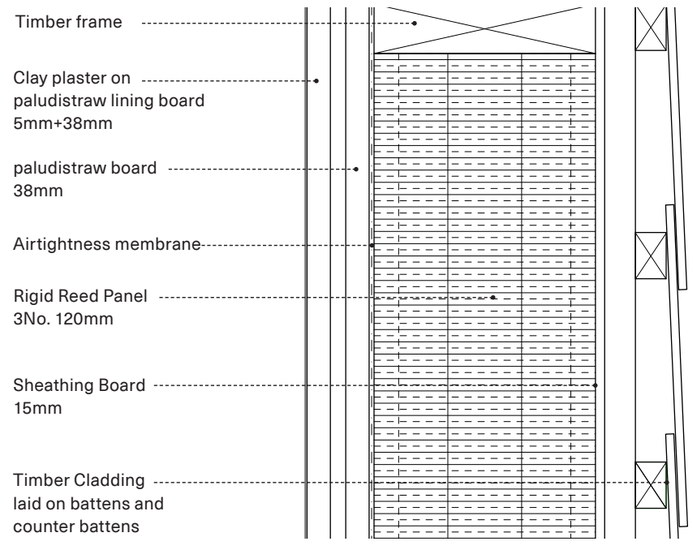
In 2021, 8,126 buildings were constructed in Brandenburg, of which 72% were for new housing and 21% related to activities on existing buildings. Material Cultures conducted an exercise to reimagine the 'business-as-usual' home by making use of a paludiculture-based biogenic material palette, details for which are shown opposite. Typically, the wall build-up of business-as-usual homes consists of a masonry cavity wall with a cement-mortar brickwork outer leaf, concrete block inner leaf, PIR insulation, PVC breather membrane and gypsum plasterboard for the internal liner. External roofing material is typically cementitious tiling.

In contrast to the business-as-usual house, the build-up of the paludiculture home uses biobased and lower embodied carbon components. The exercise looked at the application of paludiculture based products in both new build and retrofit settings. The retrofit section assumed that the building was

90 T. Kropp, K. Lennerts, M. N. Fisch, C. Kley, T. Wilken, S. Marx and J. Zak. 2022. "The contribution of the German building sector to achieve the 1.5 °C target", Carbon Management Volume 13:1, 511-530
91 Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen (BMWSB), Bundesministerium für Ernährung und Landwirtschaft (BMEL). 2023. "Handreichung Holzbauinitiative." p.10.

Business-as-usual house





Paludiculture house

an unlisted masonry construction and did not feature a basement. As most of the products using paludiculture biomass are still in an initial prototyping phase, rigid reed panels which are readily available on the market today (such as by Hiss Reet) was selected for the study. The wall build-up of the paludiculture-based home consisted of a timber frame, timber external cladding, rigid reed insulation panels with clay plaster internal finishes and the addition of a thatched reed roof for the new build construction.

Having understood how construction materials derived from paludiculture biomass could be integrated into new build and retrofit construction systems, as shown on page 93, the Sernitz Torfwiese site was evaluated for its potential to cultivate paludiculture materials for a regional, biobased construction industry. The purpose of the assessment was to quantify the amount of paludiculture-based construction materials that could be harvested from the Sernitz Torfwiese site in a year, as well as the number of homes per year that could be constructed using that volume of insulating and lining materials.

For the purposes of this land use study, a new build detached two-storey house was assumed as the case-study model for which material quantities and land use and impact were calculated. The detached two-storey house was chosen due to its ubiquity in most urban and rural settings, with an awareness that it is a baseline standard, or worst case scenario in terms of the density and material efficiency of the typology. As such, the land usage areas calculated per house represent a relatively inefficient use of paludiculture materials from the site, with denser typologies such as apartment buildings offering greater efficiencies by requiring fewer hectares of paludiculture cultivation per person and per home. Denser housing typologies will be needed to better address the climate crisis, and many of these typologies are already commonplace in Brandenburg's new-build sector.

New Build

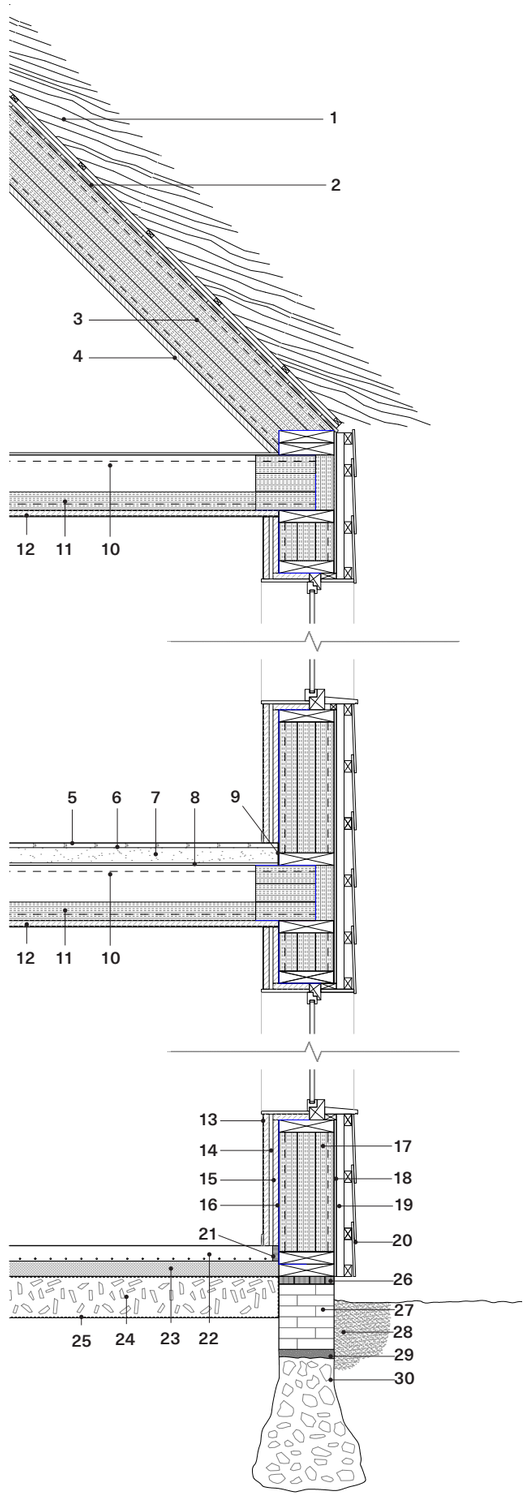
Roof
1 400mm Reed thatch
2 20mm Pine sarking boards
3 360mm Deep JJI-Joist (@400mm centres) with 3No. 120mm rigid reed panel
4 38mm Paludiculture straw board

Floor
5 20mm Tongue and groove alder timber floor boards
6 0.5mm Cork underlay
7 100mm Earth screed
8 15mm Sheathing board
9 Rubber connection for acoustic decoupling
10 360mm Deep JJI-Joist vertical ends to cassettes
11 120mm Rigid reed panel
12 38mm Paludiculture strawboard with clay plaster finish

Wall
13 38mm Paludiculture strawboard with clay plaster finish
14 Installation/cabling zone
15 38mm Paludiculture straw board
16 Airtightness membrane
17 360mm Deep JJI-Joist vertical ends to cassettes (@400mm centres) infilled with 3No. 120mm rigid reed panel
18 15mm sheathing board
19 50/75mm counter battens
20 Pine shingles laid on battens

Slab
21 40mm Cork strip
22 100mm Clay floor with underfloor heating
23 100mm Reinforced lime slab
24 Recycled glass insulation
25 Geotextile

Foundation
26 50mm x 100mm Foam glass block
27 Brick foundation
28 Gravel with protective membrane
29 Levelling sand
30 Hardcore of local stone and aggregate



Unlike conventional construction systems which aim to eliminate moisture entering the building fabric entirely, the propositional sections presented follow breathable construction principles[92]. This means that permeability is designed within the building fabric to allow the inherent moisture regulation properties of biogenic materials to best perform. For this reason, Damp Proof Courses (DPC's) which prevent moisture entering the build up like a plastic skin overlaid on the build-up, have been intentionally omitted. Similarly if the entire construction is breathable, the ventilation cavity in the roof build-up has been omitted. The traditional Lehmwickeldecke floor system represented in the retrofit section follows guidance for installing Rigid Reed Panel insulation by the manufacturer Hiss Reet.

92 Building construction proofreading by Prof. Helga Blocksdorf, IKON TU Braunschweig

Retrofit

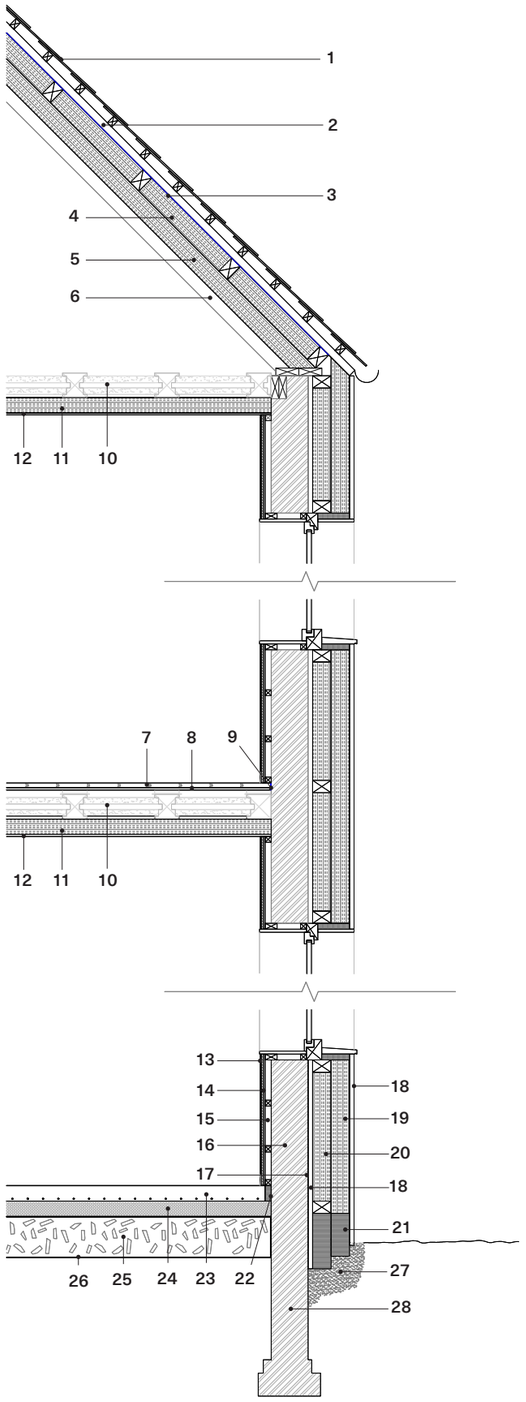
Roof
1 Roof tiles laid on laid on 25/50mm counter battens
2 25/50mm battens
3 Airtightness membrane
4 120mm Rigid reed panel above rafters fixed between 80x120mm battens
5 120mm Rigid reed panel between rafters
6 Existing roof rafters

Floor
7 20mm Tongue and groove alder timber floor boards
8 3mm cork underlay
9 Rubber connection for acoustic decoupling
10 Existing lehmwickel decke spanning between timber joists
11 100mm Rigid reed panel
12 Clay plaster finish

Wall
13 Clay plaster rendered on a backing board
14 15mm sheathing board
15 Timber packers (if masonry wall is uneven)
16 Existing masonry wall
17 Airtightness tape over cracks/junctions
18 30mm Lime render
19 120mm Rigid reed panel
20 120mm Rigid reed panel fixed between 80x120mm battens
21 Foam glass blocks

Slab
22 40mm Cork strip
23 100mm Clay floor with underfloor heating
24 100mm Reinforced lime slab
25 Recycled glass insulation
26 Geotextile

Foundation
27 Gravel with protective membrane
28 Existing masonry foundation



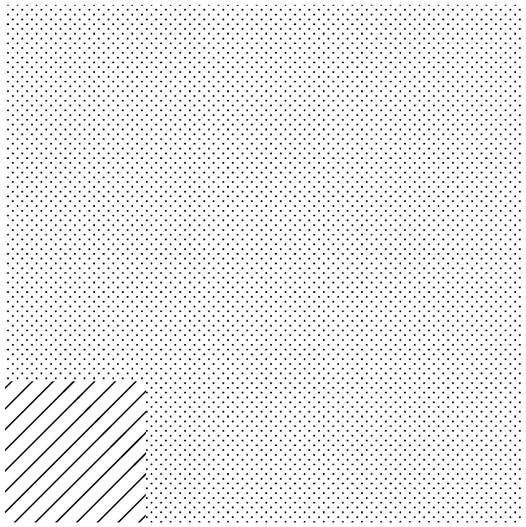
4.3 Land use impact study

Using the 80 ha Sernitz Torfwiese site as a case study, Material Cultures' analysis explores the potential of paludiculture practices to deliver climatic, ecological and economic benefits when applied at scale. The exercise found that roughly 1.2 ha of cultivated reed was required to produce the construction materials necessary to build a detached two-storey house. This includes 658m^2 of rigid reed insulation panels used to insulate the walls (achieving a U-value of 0.16[93]), floor, soffit and roof, and a 400mm-thick reed thatched roof.

Aside from the value from the sale of paludiculture biomass, it is important to consider the Sernitz Torfwiese site in terms of the habitats it nurtures, and the flora and fauna that live there. As part of this exercise, 10% of the site was assumed to be left unmown in a rotational fallow, leaving 72 ha of reed for cultivation. Although the un-mown 10% would result in a reduction in potential yield, it has the essential benefit of enhancing biodiversity by supporting different species that are either sensitive to mowing, dependent on old biomass litter or which use old reed stems in the winter.[94]

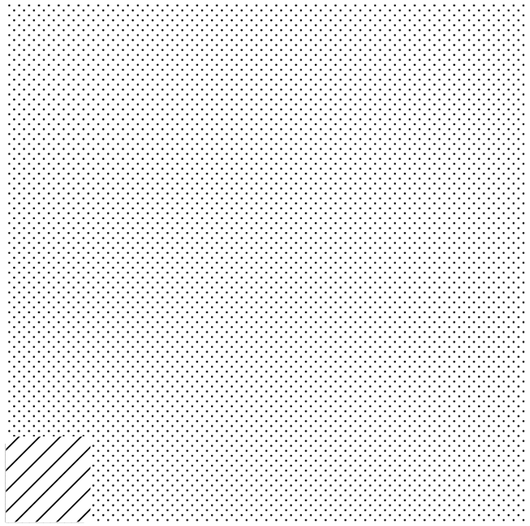
To conclude, findings from Material Cultures study indicate that the Sernitz Torfwiese 80 ha rewetted peatland site has the potential to annually cultivate reed for 60 two-storey detached dwellings.

93 This U-value was acquired using the Ubakus U-value calculator
94 Interview with Dr Franziska Tanneberger by Material Cultures and Bauhaus Earth conducted on Wednesday 22 March 2023



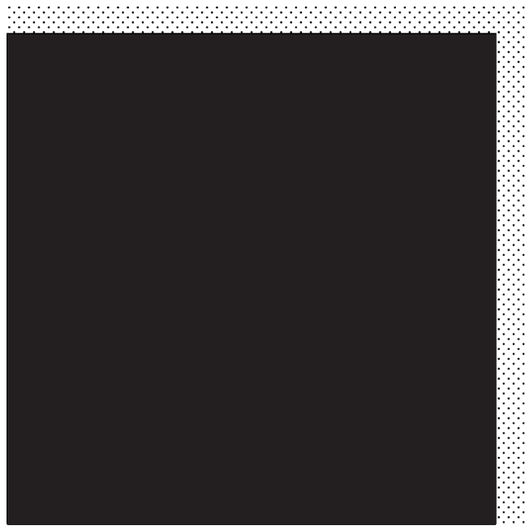
737m^2

of 120mm rigid reed panel produced by reed harvested from 1ha



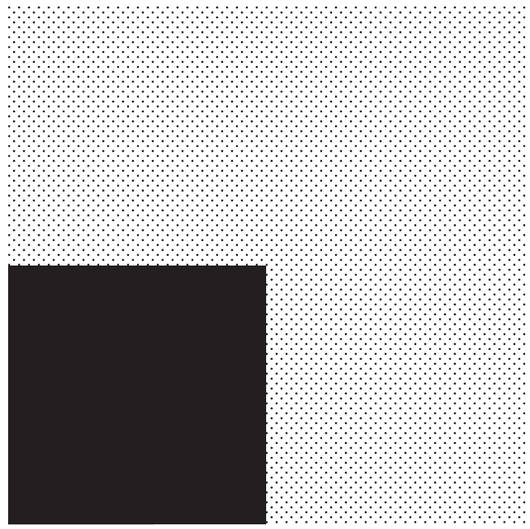
228m^2

of 400mm thatch produced by reed harvested from 1ha



8940m^2

of land to cultivate the reed for the 120mm rigid panel for 1 house



2890m^2

of land to cultivate the reed for the 400mm thatch for 1 house

Reed Insulation
8940m²

Land required is needed to cultivate the reed for the 120mm rigid reed panel in a detached two storey dwelling

Product	120mm Rigid Reed Panel
Crop	Reed
Average harvest yield	13700 kg/ha
Component	Insulation
Form	Dry bound panel
Density	155 kg/m³
Thickness	0.12m
Volume of reed harvested per ha	88.4m³/ha
Area of reed panel per ha	737m²/ha
Area of reed panel in model house	658m² [435m² in walls, 31m² in soffit, 34m² in floors, and 158m² in roof]

Reed Roof Cladding
2890m²

Land required to cultivate the reed for the 400mm thatch roof on a detached two storey dwelling

Product	Reed Thatch
Crop	Reed
Average harvest yield	13700 kg/ha
Component	Cladding and Insulation
Form	Straight straw
Density	155 kg/m³
Thickness	0.4m
Volume of reed harvested per ha	88.4m³/ha
Area of reed thatch per ha	228m²/ha
Area of reed thatch on model house	66m²

1.2 ha
of cultivated reed

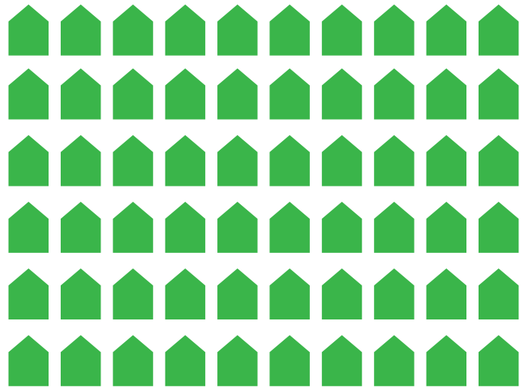
80 ha
Total area of the Torfwiese site

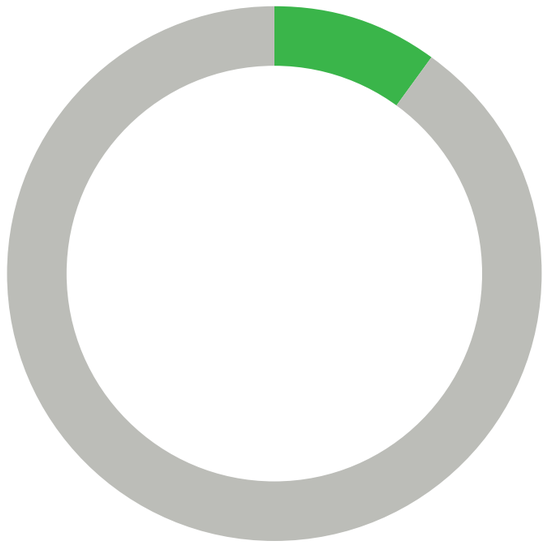
72 ha
available area of the Torfwiese site for cultivation

1 house
insulated with rigid reed panel + fitted with thatch roof

10%
of the Torfwiese site allocated for wildlife

60 houses
insulated with rigid reed panel + fitted with thatch roof





5 Barriers/Opportunities

Rewetted peatlands can generate income for farming communities and help to decarbonise the construction sector, supporting the delivery of housing. If the approach outlined in this report were to be applied at scale, Berlin-Brandenburg could be at the forefront of urgent and effective decarbonisation of both the built environment and agricultural sector within Germany.

5.1 Barriers

1 Supply and demand

Limits in demand create a barrier for the expansion of a paludiculture material supply chain. A major block for landowners in rewetting land is the perception of a limited demand for paludiculture-derived biomass, which is at present mostly used as animal bedding and fodder, and for biomass energy generation. While agricultural subsidy mechanisms play an important role in incentivising the rewetting of drained peatlands, they alone cannot compensate for the loss of revenue which farmers will likely experience by moving from arable to paludiculture farming.

The manufacturing industry is also trapped in a cyclical demand and supply loop. Without greater demand for paludiculture materials, farmers will not be incentivised to transition their land to paludiculture systems, and without greater supply of these products within the market, they will continue to exist as fringe materials. Existing construction material manufacturers are risk-averse and reluctant to shift their production lines to paludiculture biomass without a guarantee of consistent paludiculture supply and sales. Currently, paludiculture construction materials remain relatively unknown, with very few demonstrator projects in place to demonstrate their efficacy.

2 Capital investment

For some German federal states, funding exists under the EU's Common Agricultural Policy (CAP) for machinery to process paludiculture crops. Farmers and processors in Brandenburg have the option of drawing on the ProMoor[95] scheme which provides an up to 80% subsidy for water management measures, and an up to 60% subsidy for demonstrator projects including the conversion of existing technology, the purchase of new technology, the adaptation and testing of processing systems, and the establishment of reed and cattail crops for cultivation.

In addition, the Greifswald Moor Centrum reports that national funding programmes are also set to come online shortly to fund capital investments in machinery, for harvesting, processing and use of wetland plants. New paludiculture harvesting machinery is estimated to cost upward of 400,000 euros, and farmers need access to large enough tracts of land to justify this investment.[96] Cooperative model (See: Section 5.2 Opportunities, page 110), where the cost of machinery is distributed across cooperative members, are a potential solution.

A previous attempt to launch compressed straw board products in the region was unsuccessful due to high-capital startup costs, while the limited size of the biobased building market has historically led to significant losses.[97] In an interview with the authors of this report, Marcel Burgstaller, CEO of compressed board manufacturer istraw (See: Section 6, page 126) reported that initial investment costs can be close to 2 million euros.[98]

For existing companies who manufacture and sell similar biobased products and may have capacity to integrate paludiculture products into their lines, significant capital investment would still be required to procure new machinery, tooling, systems and techniques.[99] In both cases, whether for new or existing manufacturers, a growing sector demand for paludiculture and biobased materials would need to be forecast to provide confidence to invest.

95 Investitionsbank des Landes Brandenburg. "Bog Conservation Program." Retrieved June 2023, from https://www.ilb.de/de/infrastruktur/alle-infrastruktur-foerderprogramme/moorschutzprogramm/

96 Interview with Anke Nordt by Material Cultures and Bauhaus Earth on Friday 10th March 2023

97 Interview with Marcel Burgstaller by Material Cultures and Bauhaus Earth on Friday 10th March 2023

98 ibid

99 Interview with Jan Peters, Fabian Frucht and Dr Nina Seifert by Material Cultures and Bauhaus Earth on Thursday 16th March 2023

3 Certification and regulations

The majority of construction materials for consumer sale must fulfil requirements laid out in the DIN standards and the German Building Regulations (the Bauordnung, or BauO). However, many paludiculture materials and components are new to the market, or are yet to undergo material testing and certification. Without evidence-based testing and data comparable to commonly used building materials, challenger paludiculture materials will not be able to reach mass market potential and compete with existing products.

In addition, Environmental Product Declaration (EPD) statements are required by German law, and Life Cycle Analysis (LCA) documentation is increasingly sought by design teams and clients. Testing for both of these certification systems is often costly, creating a barrier to entry for material innovators working in the biobased sector.

The cost of putting materials through the fire, structural and weather testing necessary to achieve certification can be prohibitive for small material manufacturers and innovators, and create a significant obstacle in their route to market. But it remains the case that achieving certification is an essential requirement before large-scale housebuilders and industry suppliers can be approached and expected to use paludiculture materials in their developments.

4 Misconceptions

Several misconceptions exist in the general understanding of biobased materials in general, and paludiculture materials specifically. Many paludiculture materials and products are generally unknown, or considered archaic, such as the practice of reed thatching.Other concerns range from the threat of pests and mould to concerns around safety, durability and fireproofing. While biobased materials can be naturally combustible, other materials like water reed, are considered to have a natural resistance to fire, due to a high silica content. Treatments can significantly improve biobased materials' response to fire, moisture and pests. Further research would be beneficial in addressing ongoing misconceptions, as well as knowledge gaps regarding combustibility and combustibility standards.

5 Costs

Biobased materials including those derived from paludiculture can be more expensive than their carbon-based counterparts and the limited availability of labourers experienced and skilled in the use of biobased materials increases costs for contractors and developers, who price the risk in using unfamiliar materials into tender returns. However, as use becomes more widespread and manufacture more established, production costs are expected to fall, which will in turn be passed on to homeowners. As demand increases, economies of scale in production can be taken advantage of and it is reasonable to assume that, in tandem with regulatory reform, material costs will decrease.

5.2 Opportunities

1 Regulatory Levers

German Building Regulations, (the Bauordnung, or BauO) do not currently regulate against the use of high embodied carbon building materials. Without regulation, the industry relies on the individual actions of clients and homeowners and their attitude to the environment, to generate demand for their products and systems. Until regulatory change is made in favour of low carbon materials, costs and risks will continue to be placed on individuals.

Despite this current situation, there are currently a number of regulatory levers at the disposal of the country, at both state and federal level. As a federation, Germany comprises 16 states, each with their own constitution; allowing German states to implement state-wide policies that can exceed the ambition of national policies.

At a federal level, the Ministry for Housing, Urban Development and Construction has established the Bewertungssystem Nachhaltiges Bauen (BNB) sustainable building assessment system in use for public buildings such as schools and offices. The assessment system is mandatory for all new federal buildings along with complete refurbishments and could be amended to promote low embodied carbon and biobased building materials. Planning policies and building regulations can be used as effective tools to drastically increase the demand and use of low embodied carbon building materials, such as those which can be produced using paludiculture feedstocks. Global examples include:

- The Part Z campaign led by pressure group Architects Climate Action Network (ACAN), promotes an additional set of regulations against high embodied carbon construction in buildings. ACAN proposes UK Building Regulations be expanded to include requirements to assess, report, and reduce embodied carbon, within a new part: 'Part Z: Embodied Carbon Emissions'.
- Environmental Product Declarations: Enforcing the use of Environmental Product Declarations, as is mandatory in Copenhagen, or whole Life Cycle Analyses (LCA's) of construction, as is necessitated in the Netherlands.[100]
- Changes to planning police to directly mandate in favour of certain building materials, as demonstrated in France, where regulations demand that new public buildings include a certain percentage of timber in their construction.

2 State Subsidies

Protection of peatlands is devolved to state governing bodies, who can use EU CAP funding to subsidise landowners who chose to voluntarily resaturate their land. More recently the Federal Government has instigated several initiatives to further support the rehabilitation of peatlands, such as the Federal Environment Ministry's 'International Climate Initiative for Peatland Protection'. With a dedicated fund of just under 2 million euros,[101] a fraction of that dedicated to forest landscapes (65.6 million euros),102 the efficacy of this programme remains to be seen, however, the Michael Otto Foundation is optimistic. They report that whilst the eligibility criteria for paludiculture farming from agricultural subsidies are yet to be established, landowners are aware of the process required to apply for funding.[103]

Aside from this scheme, this year the German government announced their 4 billion euro Aktionsprogramm Natürlicher Klimaschutz (ANK), of which 1 billion euros has been allocated for farmers who undertake voluntary measures to raise water levels. The programme will also provide support for existing wetland infrastructure and the development of new value chains for peatland conservation.

100 S. Attia, M. Santos, M. Al-Obaidy and M. Baskar. 2021. "Leadership of EU member States in building carbon footprint regulations and their role in promoting circular building design"

101 UNEP. 2019. "Germany Announces Support for Peatlands: A Natural Solution for Climate Action." Retrieved June 2023, fromhttps://www.unep.org/news-and-stories/press-release/germany-announces-support-peatlands-natural-solution-climate-action

102 Federal Ministry of Food and Agriculture. 2021. "Forest Climate Fund"https://www.bmel.de/EN/topics/forests/forests-in-germany/forest-climate-fund.html

103 Interview with Claudia Bühler and Dr Tim Eckhardt of the Michael Otto Environmental Foundation, by Material Cultures and Bauhaus Earth on Tuesday 21st March 2023

3 Carbon Credits

Carbon credits are measurable, verifiable emission reductions from certified climate action projects, articulated as a monetary value. The carbon value of conventional fodder production on drained peatlands is estimated to be 585 euros per hectare. On restored peatlands, however, data shows that the cumulative value when encompassing avoided emissions could be between 595 to 1750 euros per hectare, depending on the type of paludiculture crop grown.[104]

Carbon credits or natural capital payments are controversial. Methodologies for calculations are largely unregulated and carbon credits have been used to offset the continuation of energy intensive, business as usual practices across the globe, as opposed to directly reducing emissions at source. The high capital costs of paludiculture cultivation and material processing, however, mean that natural capital payments have the potential to support new paludiculture farmers and could serve as a useful private sector-led incentive in lieu of government intervention.

MoorFutures[105] is a long term carbon credit initiative developed from a 2013 study which assessed ecosystem services from peatland rewetting. Through the study, it was possible to assess the reduction of greenhouse gas emissions from restoration of peatlands, as well as the benefits for groundwater storage, flood mitigation, landscape cooling effects through evapotranspiration, nitrate release and biodiversity benefits. The Greifswald Mire Centre is involved in meta-analysis of source data to ensure that carbon credit methodologies can be applied to specific peatland sites.[106]

4 Alternative models

The absence of established markets is a strong deterrent to farmers who would otherwise consider farmland rewetting. However, the potential to generate significant income from high value paludiculture products could serve as a valuable incentive in making this land use change. Establishing locally-based material processing and manufacturing centres could bring skills and jobs to places where they are most needed and ensure that the economic benefit of this industry is retained within rural communities. Unlike conventional models where farmers act solely as growers, by harnessing and taking ownership of the manufacturing process (where substantial value is added), farming communities can generate increased income.

While capital costs of processing and manufacturing are high, there are farmers in Brandenburg who are already exploring ways to bring paludiculture products to market. Sebastian Petri, of NaturwiesenHeu (See: Section 6, page 126) is currently establishing a cooperative with three Brandenburg-based farmers to grow and manufacture paludiculture strawboard products. The farmers seek to purchase production machinery from iStraw and establish their own line of compressed straw boards.

As Petri outlines, this model "proposes the farmers themselves produce the insulation boards, to sell to iStraw, who then sell on to the building industry. This is a very local, regional approach to manufacturing, and also gives lots of control to the farmers."[107] This is an emerging example of how a high value paludiculture product made by local farmers can be established.

104 Peatlands restoration in Germany – a potential win-win-win solution for climate protection, biodiversity conservation and land useAuthor:Johannes Förster mainly based on MLUV 2009, Schäfer 2009

105 Moor Futures. Retrieved June 2023, from https://www.moorfutures.de/; Page 14 Carbon Connects and Care Peat. "Towards a Carbon Credit & Blue Credit Scheme for Peatlands." Retrieved June 2023, from https://www.nweurope.eu/media/16178/carbon-credit-and-blue-credit_whitepaper.pdf

106 Interview with Dr Franziska Tanneberger with Material Cultures and Bauhaus Earth conducted on Wednesday 22nd March 2023

107 Interview with Sebastian Petri by Material Cultures and Bauhaus Earth on Friday 10th March 2023

5.3 Critical Actions

1 Support demonstrator projects:

- Owned by: Stadtverwaltung Angermünde
- Partners: Product manufacturers, Umweltstiftung Michael Otto

A demonstrator building is a critical step in establishing a tested and successful paludiculture construction industry which supports sustainable wetland restoration in Brandenburg and beyond. The delivery of a number of demonstrator projects within the region will be essential to building confidence in the paludiculture industry. These projects provide an opportunity to incorporate best practice by using wetland-derived materials while also demonstrating local supply chain potential. Establishing several demonstrators distributed throughout Brandenburg would also test the resilience and capability of different growing regions throughout the state. At this early stage of development for the paludiculture-derived construction material industry, a completed demonstrator could also address misconceptions, technical queries and testing requirements within design development and construction.

For completed demonstrator projects to be successful, it will be important to establish early partnerships with local research university clusters. Such partnerships could ensure that accurate monitoring of the demonstrator can take place and allow for the performance of the building to be recorded in terms of statutory requirements and embodied carbon in the built fabric. Existing partnerships, such as Eberswalde University's EU Interreg BEECH Power project, can be extended and a comprehensive Whole Life Cycle Carbon Assessment should be undertaken for each demonstrator.

These buildings have potential to demonstrate the potency of cross-industry and interdisciplinary collaborations, and the critical urgency of addressing the conditions and health of our landscapes. Innovative, publicly accessible demonstrator buildings would also contribute to the development of a new architectural vernacular, with aesthetics rooted in circular and biobased principles.

2 Develop standards for sustainable paludiculture cultivation:

- Owned by: Local Authorities across the region, Greifswald Moor Centrum
- Partners: Local paludiculture farmers, Succow Stiftung

Outwardly, the concept of paludiculture seems to be a sensible and climate-friendly form of land management for moors, which can preserve and restore their function as effective carbon sinks. But there are no established standards to govern or define 'sustainably cultivated' paludiculture. Without clear standards regarding sustainable paludiculture practices, the industry risks repeating the mistakes of industrial agriculture, which has seen the catastrophic damage of ecosystems and soils. It seems evident that paludiculture should not be in competition with biodiversity growth and nature conservation, but as peatland restoration projects seek to pair landscape conservation with productive paludiculture, biodiversity and sustainability standards and regulations must be established to ensure that wetland cultivation does not erode ecosystem health.

The Greifswald Moor Centrum have provided guidance for how national CAP strategies could be implemented to foster paludiculture adoption.[108] Similar guidance on sustainable wetland cultivation is needed. In the case study analysis in Section 4, 10% of the site was assumed to be left unmown in a rotational fallow. Standards for how much land is to be left unmown, and how to foster habitat development in and around paludiculture must be established and agreed.

Just as carbon credit the regulations ensure consistency in the metrics and criteria used to value land regeneration projects, an acceptable and quantifiable intensity of weltand cultivation must be agreed. A defined standard would build on recommendations in the Moorschutzprogramm Brandenburg report, for the development and implementation of nature conservation standards for paludiculture, with a view to their use in the construction industry.

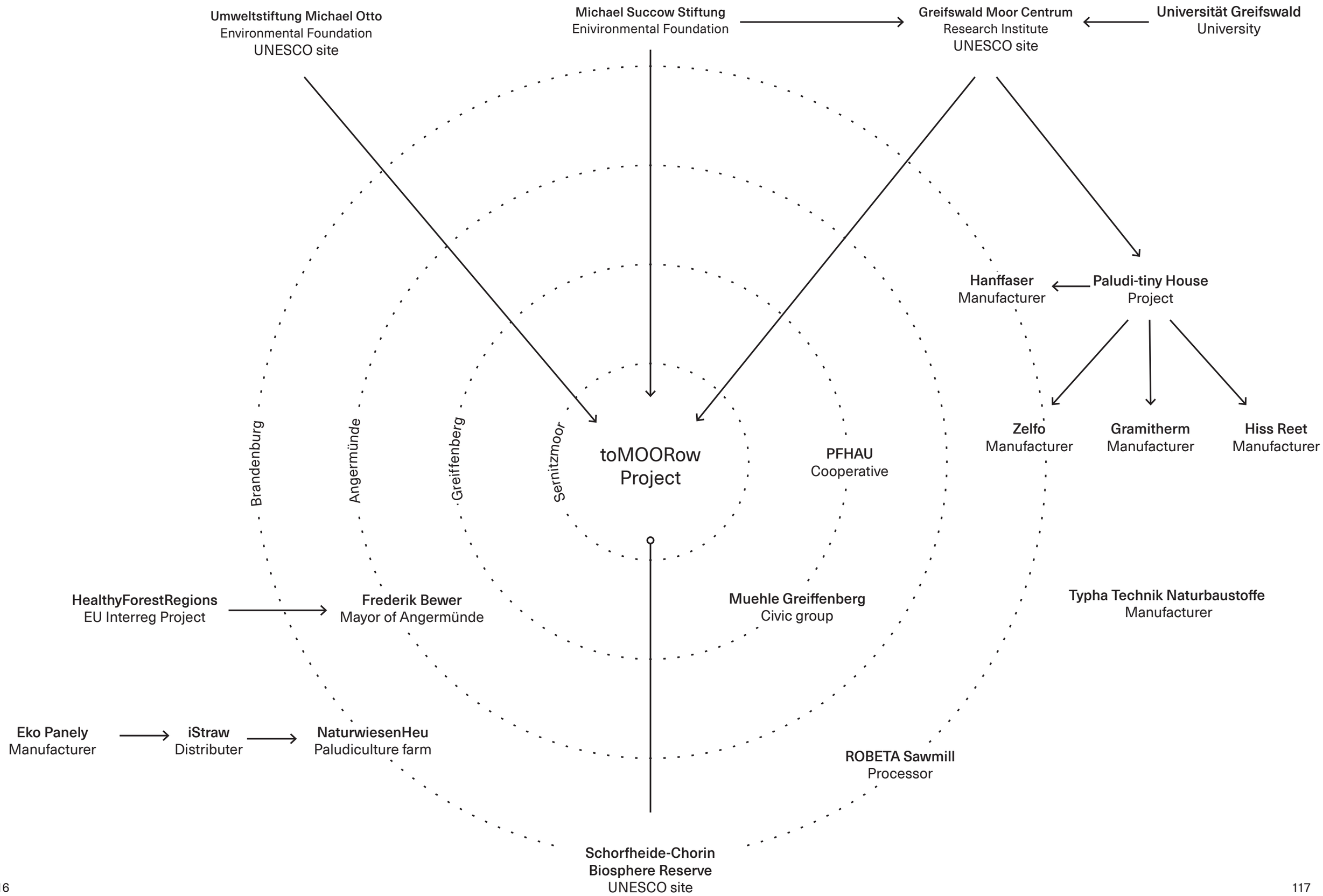
108 Wetlands Europe. 2021. "Opportunities for Paludiculture in the CAP." Retrieved June, 2023, from https://europe.wetlands.org/news/opportunities-for-paludiculture-in-the-cap/

Fig 5.1: Detail of track marks from the modified snow plough at NaturwiesenHeu

6 Consultees

As part of our research, we have been in consultation with a range of stakeholders to understand peatland restoration and paludiculture in relation to the physical, social and economic transformations underway across the Brandenburg region. Stakeholders have included partners in the toMOORow pilot project, specialists in peatland research, material manufacturers, farmers, municipal leaders and civic community groups.

Network


Umweltstiftung Michael Otto
Environmental Foundation
UNESCO site
Michael Succow Stiftung
Enivironmental Foundation
Greifswald Moor Centrum
Research Institute
UNESCO site
Universität Greifswald
University
Hanffaser
Manufacturer
Paludi-tiny House
Project
Zelfo
Manufacturer
Gramitherm
Manufacturer
Hiss Reet
Manufacturer
Brandenburg
Angermünde
Greiffenberg
Sernitzmoor
toMOORow
Project
PFHAU
Cooperative
HealthyForestRegions
EU Interreg Project
Frederik Bewer
Mayor of Angermünde
Muehle Greiffenberg
Civic group
Typha Technik Naturbaustoffe
Manufacturer
Eko Panely
Manufacturer
iStraw
Distributer
NaturwiesenHeu
Paludiculture farm
ROBETA Sawmill
Processor
Schorfheide-Chorin
Biosphere Reserve
UNESCO site

Stadtverwaltung Angermünde

Angermünde is a town of 14,000 people, located in the Uckermark district of north-east Brandenburg. In 2016, independent candidate Frederik Bewer was elected mayor of the town and during his now eight-year term, has been a proactive advocate for the region, raising awareness for a range of causes. The INSEK Angermünde 2040[109] is a development plan produced in collaboration with the town's residents, and part of Bewer's vision for transitioning the wider Angermünde area to carbon neutrality. Bewer believes that Angermunde can serve as commuter town for people from Berlin and Schwedt who are looking for a higher quality of life with access to natural amenities such as the UNESCO Biosphärenreservat Schorfheide, the UNESCO World Natural Heritage Grumsin beech forest, peatlands and lakes as well as good urban infrastructure and public transport.

Bewer has focused on the socio-economic and investment benefits of new development, but believes in a balance between this and the area's biodiversity and sustainability goals. This was highlighted in the Haus Uckermark renovation in the city centre of the city. As a public institution, the Haus Uckermark's ability to convey a public message has not gone unnoticed by Bewer, who celebrates it as an example of how to give new life to an old building. He recognises the importance of leadership to influence the direction of these developments towards more sustainable approaches, and feels that there is a new-found receptiveness to this approach due to wider awareness of climate change within society.

Angermünde, as well as the Eberswalde University for Sustainable Development, is part of a EU Interreg project called HealthyForestRegions. The municipality has focused on education as a way to demonstrate the value of safeguarding forest ecosystems to its citizens. Angermünde's contribution to the Healthy Forest Region project is being overseen by Maren Michaelsen, who is developing an education programme, pan-European youth exchanges and the brief for a forest classroom as part of this work.

109 Staatlich Annerkanter Erholungsort. 2019. "Integriertes Stadtentwicklungskonzept Angermünde 2040" Retrieved June 2023, from https://www.angermuende.de/bauen/insek/

Greifswald Moor Centrum

The Greifswald Moor Centrum (Greifswald Mire Centre) was founded in 2015 in the city of Greifswald on Germany's Baltic coast, as a collaboration between the University of Greifswald, the Michael Succow Foundation and the scientific non-profit DUENE Institute. Led by co-directors Dr Franziska Tanneberger and Dr Greta Gaudig, the Centre conducts research on peatlands including the implementation of restoration projects and also researches peatland policy for German, European and global110 contexts. Together with the UN Environment Programme, FAO, the Ramsar Convention[111] ,Wetlands International[112], and 40 other partners, the Greifswald Mire Centre is one of the founding members of the Global Peatlands Initiative[113].

Tanneberger is a specialist in fen peatlands, while Gaudig's expertise lies in nutrient-poor bog peatlands and sphagnum, a moss essential for peat cultivation. Fen peatlands are found along coastland and river valleys and are more widespread than bogs, with a broader variety of paludiculture products available from fens, such as reed, cattail, alder trees and sedges.

Fen peatlands are critical to paludiculture and peatland management, but the preservation of mires and the rewetting of drained peatlands must also be incentivised. The MoorFutures carbon certificates, which use natural capital to incentivise the rewetting of peatlands in Brandenburg, were developed by Tanneberger.

Alongside duties as director of the GMC, Tanneberger continues her work as a researcher, collecting and working with data. Her projects currently focus on the effects of rewetting and the creation of paludiculture systems for fens, including peat formation, but also covering other ecosystem benefits such as biodiversity. Tanneberger's PhD research focused on the aquatic warbler, a globally threatened fen bird species almost extinct in Germany. A part of this research is centred on species protection, which

110 Their projects in Russia have now stopped, but GMC is involved in peatland restoration and rebuilding activities around the world. Refer to https://greifswaldmoor.de/projects.html

111 The Convention on Wetlands is an intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. Refer to https://www.ramsar.org/about-the-convention-on-wetlands-0

112 Wetlands International, refer to https://www.wetlands.org/

113 Global Peatlands Initiative, refer to https://globalpeatlands.org/

Fig 6.1: Alder trees lining the Sernitz river on the Torfwiese site

involves the translocation of young aquatic warblers from Belarus to Lithuania, returning birds to restored peatlands at least partially used for paludiculture. Her latest book Das Moor, featuring the toMOORow Project's Sernitzmoor site, was published in 2023.

The Greifswald Moor Centrum has many projects concerning the implementation of paludiculture. Ecologist Anke Nordt, who has been researching paludiculture for a decade, has found that the implementation of wet agriculture comes with several obstacles, including legislation. An example of this is the EU's Common Agricultural Policy (CAP) which, while providing opportunities to support paludiculture implementation at scale[114], is dependent on National CAP Strategic Plans to realise this potential.

Nordt's background is in landscape ecology, nature conservation and their relation to ethics and economic output. Describing her work as centred on knowledge transfer, in recent years, Nordt has worked extensively with farmers, examining supply and production chains. By looking at these frameworks, Nordt has identified a key barrier to paludiculture biomass adoption being a lack of certainty regarding the end-users and companies which biomass could be supplied to; with Nordt stating that while there is a willingness among farmers to access new markets, they are often unable to identify end-users for biomass products. This is unlike supply chains for typical agricultural products such as milk and fodder, whose markets are known, and presents a significant hurdle for farmers seeking to transition to new land uses. Nordt is currently exploring the establishment of agencies and consultancies to help paludiculture products reach their market.

More recently, Nordt has been working on the Paludi MV project, implementing large-scale paludiculture within a German context which, unusually for a project of this type, has received funding for a period of at least 10 years.[115] The project is centred on two large sites of approximately 520ha and 275ha in the state of Mecklenburg-Vorpommern, north-eastern Germany. Although still in the planning phase, the project aims to rewet sites by the end of 2024 and commence paludiculture cultivation following this. As part of the project, researchers are in discussion with local farmers to assist them in adopting paludiculture management systems and the project hopes to set up production plants and chains on a regional scale to produce paludiculture biomass. Nordt's team are monitoring the impact of paludiculture for the sites' greenhouse gas emissions, water and biodiversity as well as the economic impact generated by the scheme. Nordt's research also provides monitoring assistance for a public company managing public land in Mecklenburg-Vorpommern, which has experience of rewetting projects and implementing large-scale paludiculture. Nordt's research provides assistance for further paludiculture implementation for a public company managing public land in Mecklenburg-Vorpommern, and has extensive experience of rewetting projects.

Michael Succow Stiftung

The Succow Stiftung (Succow Foundation) was founded in Greifswald in 1999 as one of the first environmental conservation NGOs. Peatlands were the focus of founder Michael Succow's research and teaching for four decades, and the Foundation's remit covers nature conservation, as well as sustainable land use and management issues. In 1997, Succow was awarded the Right Livelihood Award for protecting national parks and biosphere reserves in the former GDR. The biosphere Schorfheide-Chorin, within which the Sernitzmoor is situated, was the idea of Succow and his colleagues, who successfully managed to secure protected status for the area in the last days of the GDR prior to reunification.

Today, the Foundation is led by managing director Jan Peters and works with the University of Greifswald and other institutions on a broad spectrum of issues related to peatlands, including science, practice, advocacy and policy research.

Natural Capital is an aspect that director Jan Peters thinks will complement rewetting projects as a co-benefit, but should not be the sole outcome. Part of the Succow Foundation's work is to realise tangible and demonstrable projects that can enact change, rather than enabling compensation of emissions happening elsewhere. That said, Natural Capital does have value and can serve as a way to generate additional funds to help implement the research. Although Natural Capital and public funding is an important support for landowners, it cannot viably sustain rewetting initiatives, and

114 Wetlands Europe. 2021. "Opportunities for Paludiculture in the CAP." Retrieved June, 2023, from https://europe.wetlands.org/news/opportunities-for-paludiculture-in-the-cap/

115 PaludiMV. "Paludi-Vorhaben in Mecklenburg-Vorpommern" Retrieved June 2023, from https://www.paludi-mv.de/

Fig 6.2: A drain on the Torfwiese site

alternative revenue streams are required. The foundation is therefore working to develop the value chains from rewetted peatland to the final product and seeking stakeholders who can play a role in rewetting, from big businesses to smaller scale startups, something explored by the toMOORow initiative.

In their work with farmers the foundation has found that there is already an understanding and ability to adopt paludiculture, however due ambiguity regarding market demand to generate income there is a hesitancy to commence implementation on their land. The market in turn, is affected by high levels of standardisation and regulation in the building and materials sector which affects the ability for paludiculture biomass to be integrated into the market. The foundation believes that the necessary transition can only be guaranteed if regulations can be changed to accommodate paludiculture biomass.

Fabian Frucht oversees the site for the toMOORow initiative, a project he leads on behalf of the Succow Foundation. Frucht is an expert in moor saturation and peatland ecology. Frucht was also involved in a prior EU LIFE rewetting initiative[116] led by the Succow Foundation focused on 360 ha nature conservation in the Sernitzmoor.

In his role overseeing the restoration and implementation of pilot paludiculture practices at Sernitz Torfwiese, Frucht has been liaising with landowners to acquire the necessary permissions to implement the rewetting plan for the site. This has involved agreeing the sale of site land parcels and obtaining permission to rewet land that toMOORow cannot buy directly, through negotiated agreements with landowners. This has also required liaison with environmental and hydrological engineers to gain permission to refill ditches and raise the water level of the river.

Umweltstiftung Michael Otto

The Umweltstiftung Michael Otto, UMO, (Michael Otto Environmental Foundation) is an environmental foundation founded in 1993 and focused on land use conflicts and projects relating to forestry, agriculture, peatlands and biodiversity. The Foundation is led by Executive Director Claudia Bühler.

A major project for the Environmental Foundation is the toMOORow initiative, a partnership with Greifswald Mire Centre and the Succow Foundation aiming to rewet peatlands, demonstrate benefits for biodiversity and provide policy recommendations and increased value chains for paludiculture biomass. The latter objective is a primary focus for UMO, which recognises that the federal rewetting target of 50,000 hectares of peatland per year117 would produce a large amount of paludiculture biomass which lacks access to a direct market. These markets must be developed to ensure that landowners who currently generate income from drained peatlands are able to maintain revenue following the transition to wet peatlands.

As the decision to transition from drained to rewetted peatlands is currently voluntary for landowners, executive director Claudia Bühler is highly aware of the importance of demonstrating viable alternative income streams. This is essential not just for landowners but for industry, as both depend on one another. Businesses will not take on the financial burden of producing paludiculture biomass if a consistent supply and quality of raw material cannot be guaranteed. Likewise, landowners will only be incentivised to rewet peatlands when they can guarantee income, which cannot be offered without industrial demand for biomass. The Michael Otto Environmental Foundation is working to overcome some of these barriers in supply and demand through a collaborative pilot project with the Otto Group, Germany's biggest online retailer, to develop paludiculture derived packaging material. The Otto Group uses around 12 million packaging cartons a year and the pilot will seek to replace this packaging with paludiculture biomass-derivatives, with prototyping scheduled to begin in Spring 2023.

UMO is expanding its scope beyond the paper and packaging sector and has earmarked the construction and insulation, fibres, bioplastics and energy sectors as future growth sectors for paludiculture biomass. In collaboration with consultants Systain, the Foundation is currently identifying which sector to develop into a value chain by looking at the speed at which industries and production lines can be developed and products viably taken to market. The findings from this preliminary research will become the basis for an "alliance of pioneers". For an annual fee, UMO will support members of the alliance to develop paludiculture biomass based products and provide them with specialist knowledge and support. A second phase will see UMO

116 Refer to https://www.lifeschreiadler.de/

117 "Germany needs to rewet 50,000ha of peatland a year to achieve climate neutrality by 2050" – Greifswald Moor Centrum. 2019. "Annual Report 2018." p.3.

Fig 6.3: A detail of a drain on the Torfwiese site

target pilot projects for real world applications of paludiculture biomass in different industrial sectors. Once successful products are developed, UMO will then scale and multiply their successes to other business partners.

In light of the fact that 5-12% of national greenhouse gas emissions in the EU are generated by material extraction, manufacturing of construction products, as well as construction and renovation of buildings,118 Bühler believes that pressure from the European Green Deal for Germany to be GHG neutral by 2045, enshrined in law by the Federal Climate Change Act 2021, will force companies in the construction industry to implement change. UMO plans to target large companies that have the financial power to invest in pilot projects and the sectoral dominance to multiply results through their influence. UMO is currently establishing which companies to develop partnerships with.

Zelfo
Zelfo Technology specialises in producing fibrillated cellulose and ligno cellulosic fibres with end uses including packaging, composites and panels. Processes developed by Zelfo make use of a wide range of cellulosic and ligno-cellulosic sources, adding value to sources with little initial value and increasing the use of renewable and biodegradable materials as alternatives to plastic-based solutions. Zelfo products main uses are for moulding, paper packaging, and fibreboards

Sawmill Robeta Holz
ROBETA Holz OHG is a timber company specialising in sustainable forestry and high-quality wood products. The company makes use of sustainable raw materials and incorporates environmentally responsive processes in the production of its timber.

Hanffaser Uckermark
Hanffaser Uckermark is an industrial cooperative focused on hemp production. Cultivating 400-500 ha of land for hemp growing, harvested hemp is processed in the cooperative's factory, which opened in 1996. Cooperative members share in the profit generated through hemp production and processing and key governance decisions and processes are conducted democratically. The cooperative holds a general assembly each year to decide the distribution of earnings.

Typha Technik Naturbaustoffe
Typha Technik Naturbaustoffe was established more than 20 years ago by engineer Werner Theuerkorn to investigate typha (cattail) cultivation and use. Despite being a small company with a team of two (Werner Theuerkorn and David Theuerkorn), the company has been successful in research on the use of typha and is partially funded by the German Federal Environmental Foundation as well as other public bodies to conduct further research activity. Together with Dr Martin Krus of the Fraunhofer Institute for Building Physics IBP, they have developed a load bearing insulating board from cattail called Typhaboard. At the 2015 Milan expo a pavilion showcased their Typhaboard product in a free-standing structure.

Pfarrhaus und Co Greiffenberg
Pfarrhaus und Co Greiffenberg (PFHAU) is a communal housing project in the village of Greiffenberg, close to Brnadenburg's Sernitzmoor. Founded by Edouard Barthen and four friends in 2021, they happened upon the current site in Greiffenberg by chance while looking for a community space in Brandenburg. The church,which granted the leasehold to PFHAU for 99 years, was convinced by PFHAUs hybrid programme for the space, which does not reduce the space to private use, nor to commercial purposes. PFHAU chose a commons-oriented legal form and founded a cooperative through which they acquired the leasehold.

PFHAU consists of three large buildings; the former parsonage, a former curate's house that was used as a parish meeting place, and a barn that was rebuilt by the church 30 years ago. This barn is the newest building on the site and the intention is to continue using it as an events space accessible to people from the village and the wider region. PFHAU was one of the first projects of its kind in this part of Brandenburg, with a second cooperative recently established In Greiffenberg renovating an even older historic building for reuse.

The cooperative will share one building as a flatshare and it is stipulated that it can neither be used as a weekend retreat or as a permanent home – with the intention that

118 European Commission – Internal Market, Industry, Entrepreneurship and SMEs. "Buildings and Construction." Retrieved June 2023, from https://single-market-economy.ec.europa.eu/industry/sustainability/buildings-and-construction_en

Fig 6.4: Paludiculture biomass harvested and baled on the Torfwiese site

members will live between Greiffenberg and Berlin. Conversely, the second house will be rented out on a temporary basis to a collective of 30 people from PFHAU's larger network for project-based work or leisure. The cooperative are currently renovating the space and are trying to integrate ecologically beneficial materials into this process.

istraw

istraw is a company promoting the use of straw-based products in the construction industry. It is led by CEO Marcel Burgstaller whose first experience with straw in the building industry was in 2006, when he planned and built seven houses out of straw bales. Since 2013, his focus has been on building materials utilising straw. Burgstaller's goal is for all products istraw distributes to be 100% biodegradable.

In 2022, Burgstaller was approached regarding the use of materials and biomass from wetlands. Having previous experience working with compressed reed panels to build a house as part of KAITO Projects' SENtypha project in Senegal in 2016, Burgstaller tested around 20 paludiculture materials and found that nearly all were usable for construction panels. The success of these tests suggests that rather than a technical issue, other factors such as regulatory and economic conditions prevent value chains from paludiculture biomass being realised.

istraw has access to German-based production lines and is looking to establish new production lines in Bavaria, Brandenburg and the Netherlands. istraw is also a distribution partner of EkoPanely, a compressed straw board manufacturer based in the Czech Republic. However, the company is exploring the possibility of developing a localised production network to fulfil all requests from developers who want to use the panel in Germany and internationally. Burgstaller believes that, subject to investment, istraw could readily set up 50 lines a year and advocates for production lines to be in the hands of local paludiculture farmers, with istraw establishing the network of production lines and overseeing distribution of the products. An emerging pilot project between istraw and NaturwiesenHeu, a paludiculture farm in Brandenburg, will establish a production line as part of a farmers' cooperative.

NaturwiesenHeu

NaturwiesenHeu is a 286 ha paludiculture farm in Kremmen, Brandenburg, cultivating hay and a mix of grass, sedge and reed. Owned and managed by Sebastian Petri, the farm includes meadows and pastures for 140 cows, 32 water buffalo, as well as horses, chicken and geese. Petri's herd of water buffalo are kept to manage the wetlands rather than for slaughter and are able to move across wetlands with specially evolved webbed hooves.

The restoration of this moorland site initially fell to Petri's parents, who took responsibility for the site in 1995 along with a number of nature conservation associations, but were eventually left as sole managers. Petri, who received the German Landscape Conservation Award in 2020, took over the site in 2015, and with the support of Brandenburg's ProMoor subsidy, was able to customise a snow plough into a crawler, allowing harvesting of wetland biomass without sinking.

Currently, Petri's crop mix is suited to horse feed due to its high proportion of reed canary grass, selling around 2,500 round bales a year. If he were to expand, as he and his partner intend, additional markets will need to be found for the increase in sedge, rush and reed biomass expected, as these are not suited for animal feed. Petri is in consultation with various groups to find viable options. This includes discussions with producers of hydrogen from biogas, fibres for bioplastics, and bio-boards with istraw. The Petris also need to convince their neighbours to adopt paludiculture practices if they wish to rewet more land.

Petri, who prior to farming trained as an agricultural economist, has been investigating the highest water level that he can cultivate paludiculture materials within. He describes that for the whole year, there is ideally 10cm of water underground, with 30-40cm water overground in winter. Harvest is typically in mid summer – from the end of June to the beginning of July – and the biomass is harvested into round bales of hay.

Currently Petri is spearheading a cooperative with three other farmers who are looking to purchase compressed straw board manufacturing machinery and establish their own production line for a Brandenburg paludiculture strawboard product. This is an exciting development which would establish a high value product stream for local farmers in and around the wetlands.

Fig 6.5: Processed paludiculture biomass fibres

Photography Credits

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