



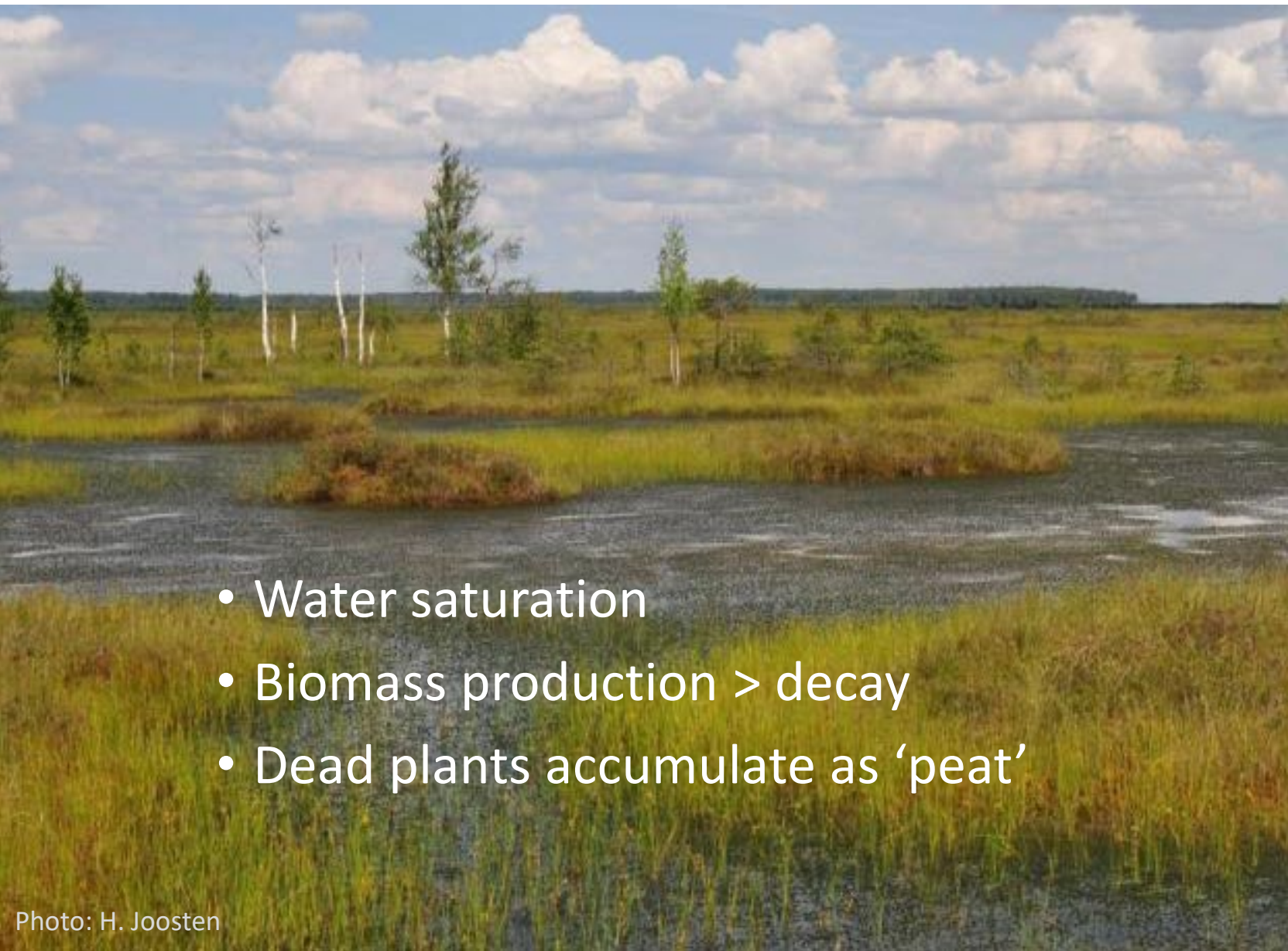
past – present – future



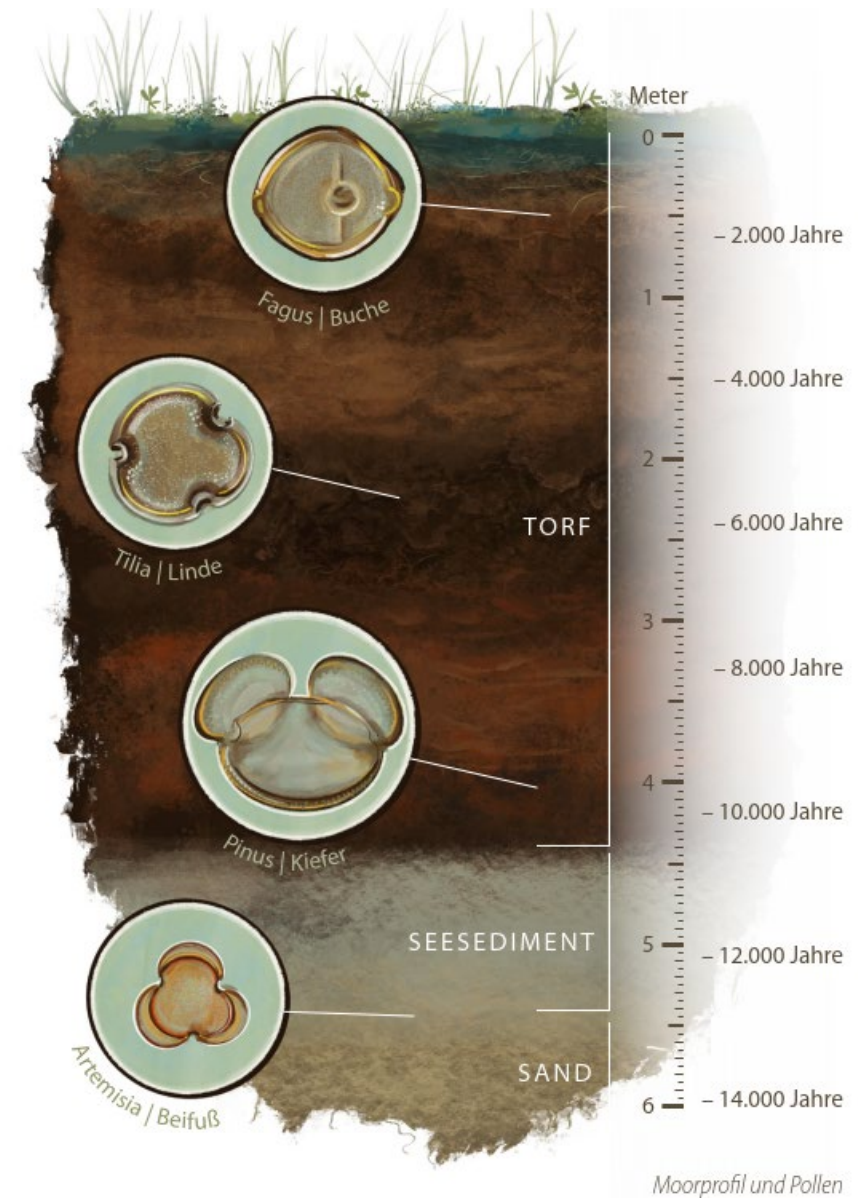
# Paludiculture - an introduction

Sabine Wichmann

# Living peatlands ('mires') capture carbon



- Water saturation
- Biomass production > decay
- Dead plants accumulate as 'peat'



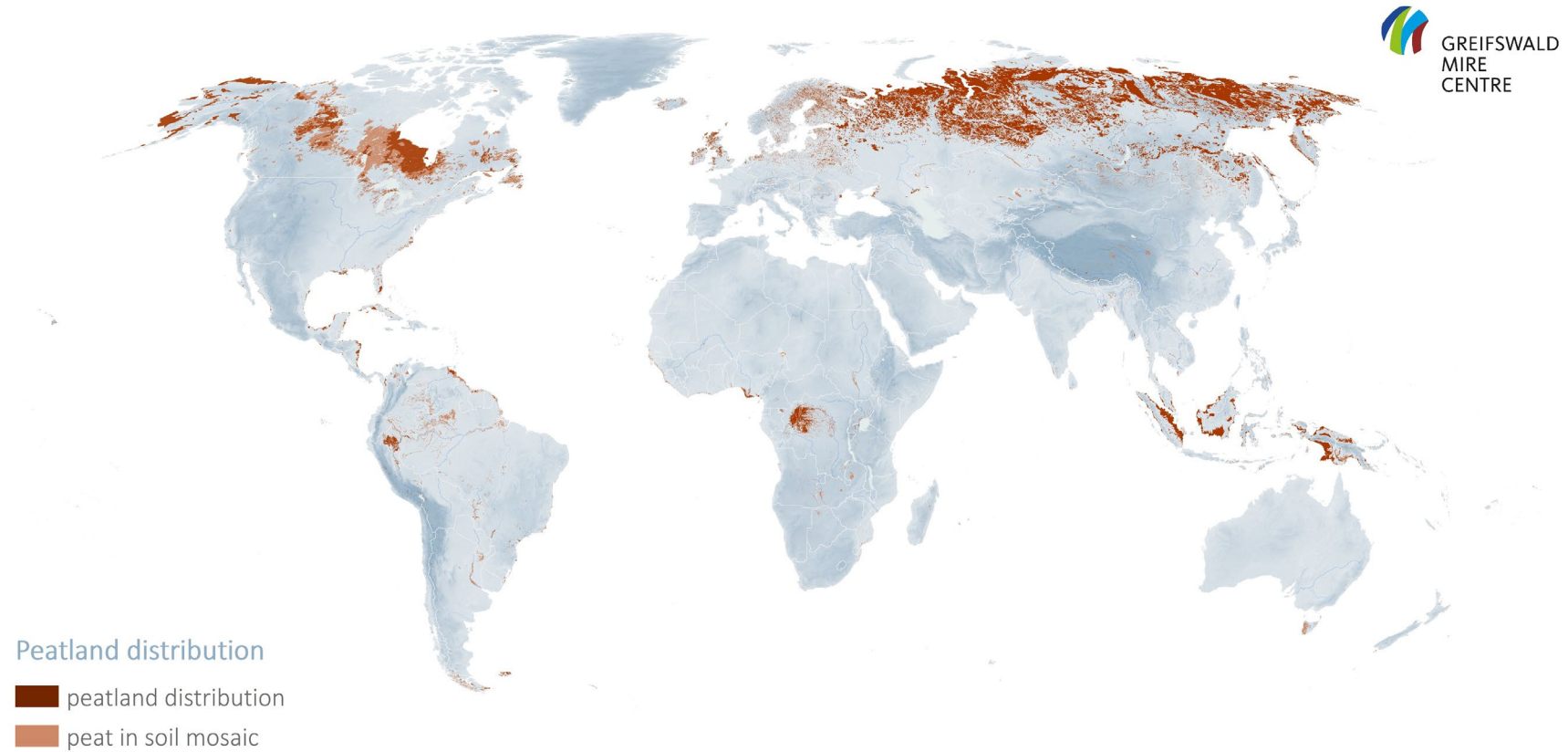
# Drained peatlands = large GHG source

- Drainage for agriculture, forestry, peat extraction...
- Destroys long-term carbon store
- Peat is oxidised →  $\text{CO}_2 \uparrow + \text{N}_2\text{O} \uparrow$

# Peatlands

in their natural state:

- Globally: 85-90 %
- Europe: 54 %
- DE: < 2%



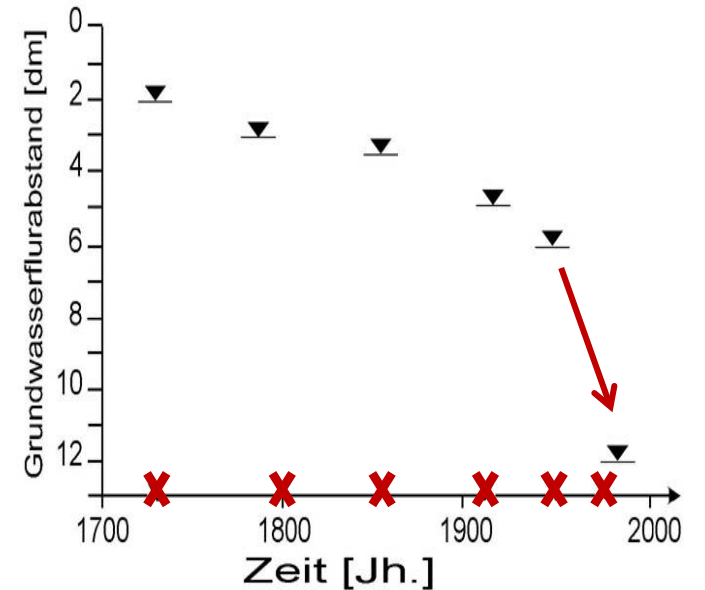
# Drainage → successive degradation

Habitat loss  
Soil degradation  
Peat loss  
Nutrient emissions  
GHG emissions



Biodiversity loss  
Loss of productive land  
Subsidence  
Aquatic eutrophication  
Climate crisis

Lowering of the groundwater level  
(Randow-Welse-Bruch/DE)



✘ Melioration action  
▼ Groundwater level below surface

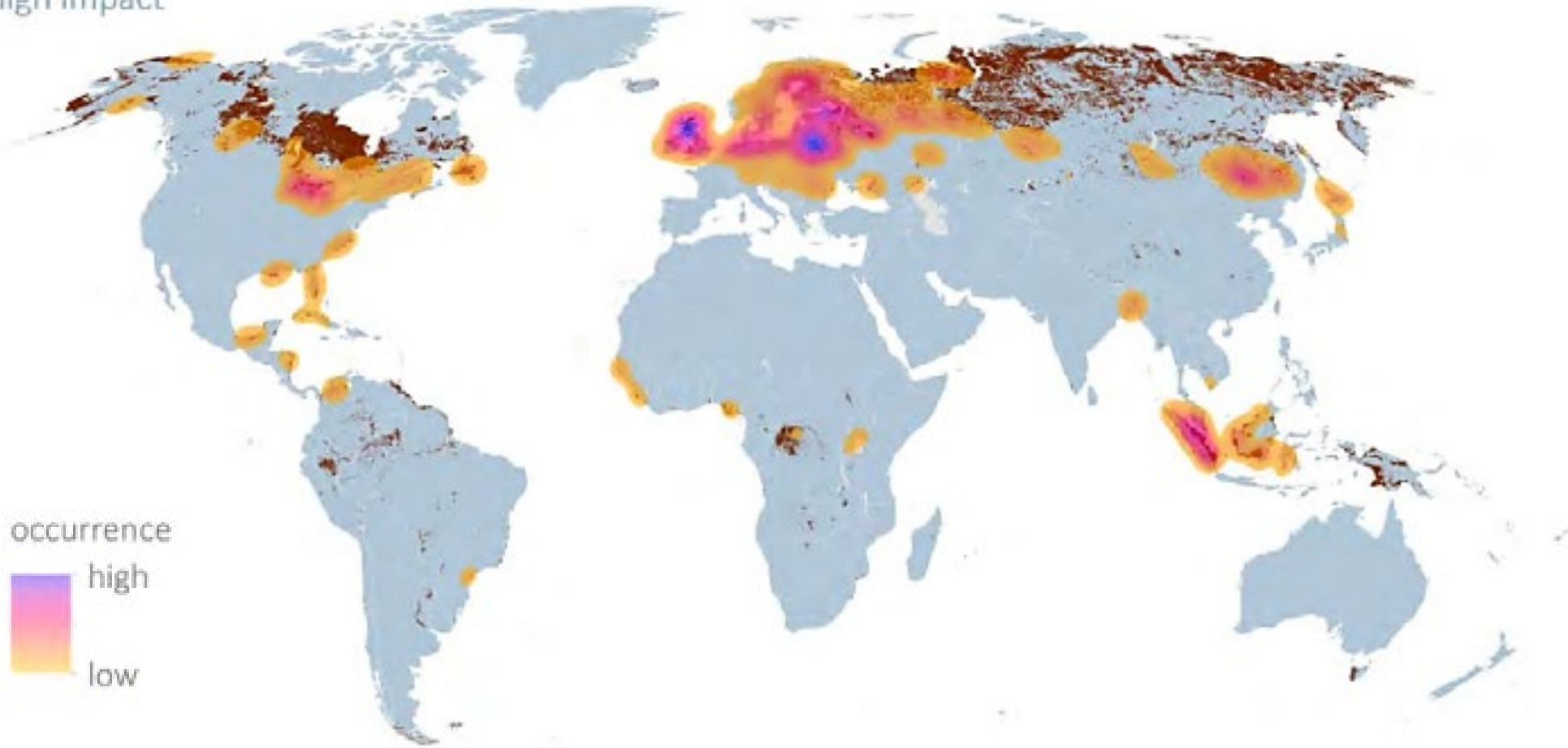
(Lehrkamp 1989, in Succow & Joosten 2001)



Bundesarchiv, Bildautoren: Biscan, Heilig, Bartocha

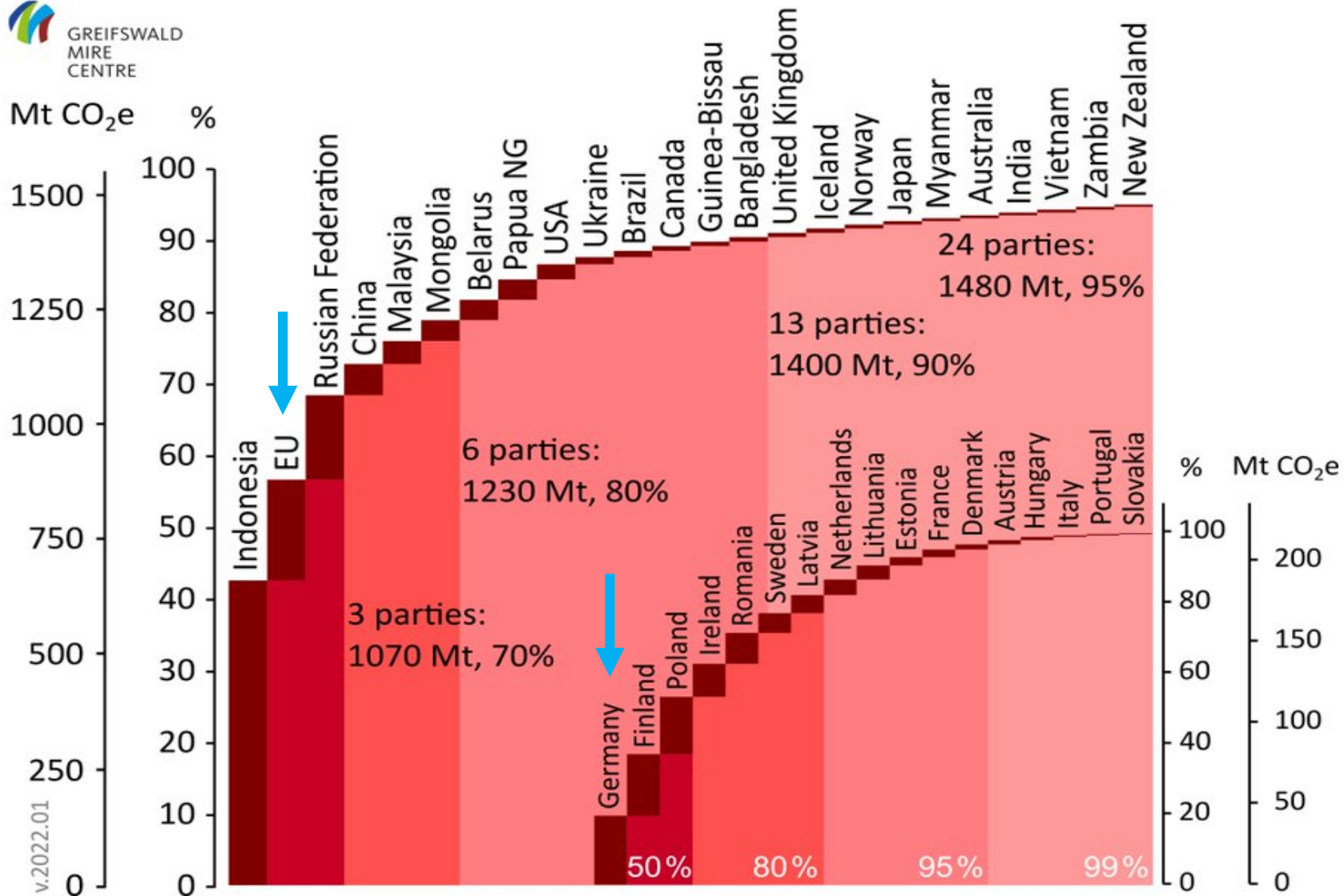
# Europe = global hotspot of human impact on peatlands

high impact



UNEP (2022) Global peatland assessment. Data from GPD, compiled by GMC

# GHG emissions from drained peatlands



**Global top emitters:**  
 1<sup>st</sup> Indonesia  
 2<sup>nd</sup> EU

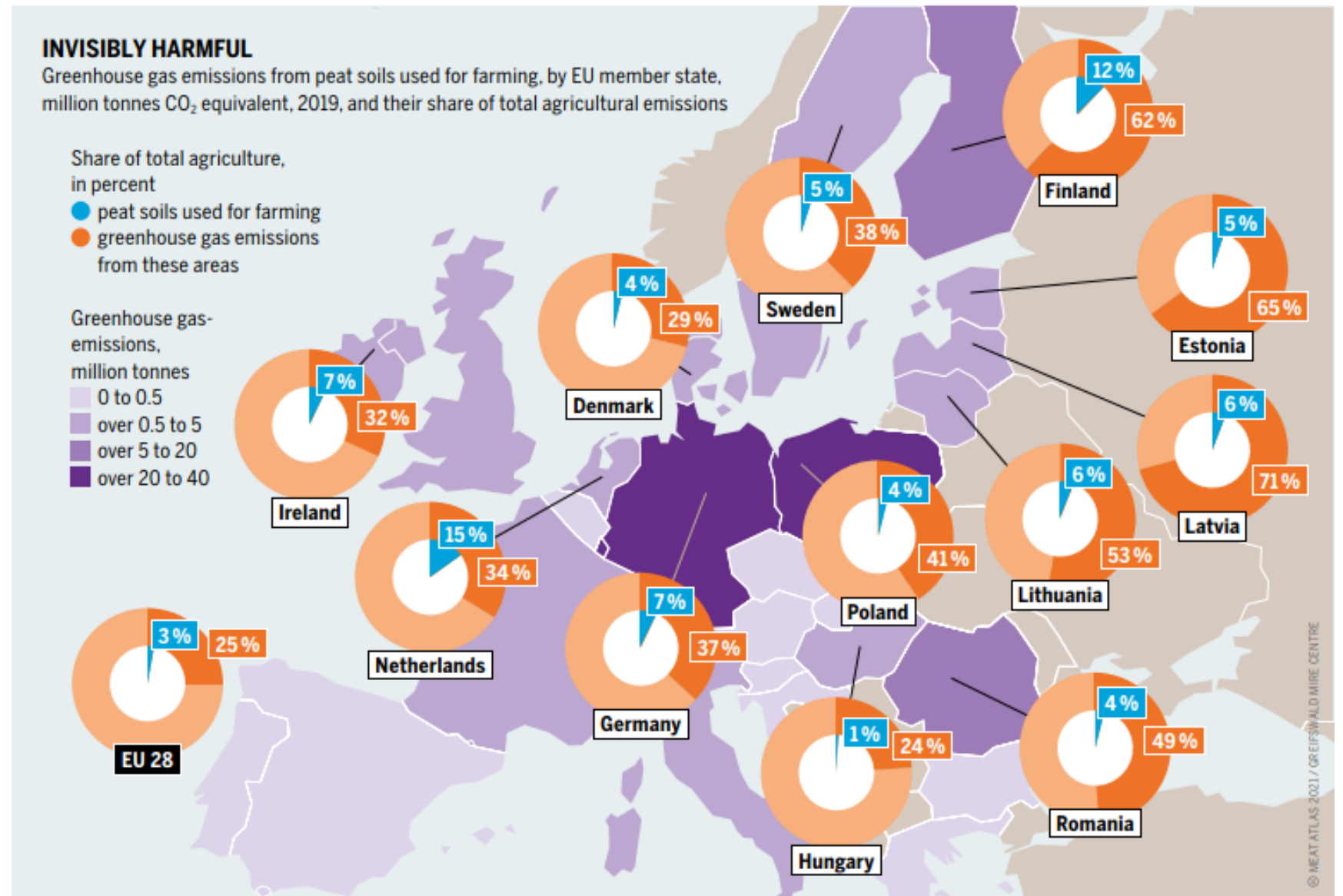
**within the EU:**  
 Germany is 1<sup>st</sup>

# Agriculture – major driver for peatland drainage





# Low share of agricultural land – but high share of emissions



**EU 28**

3% land

25% emissions

# Agricultural subsidies provide public money for climate damage

→ German peatland agriculture causes a **climate damage of € 7.2 billion**

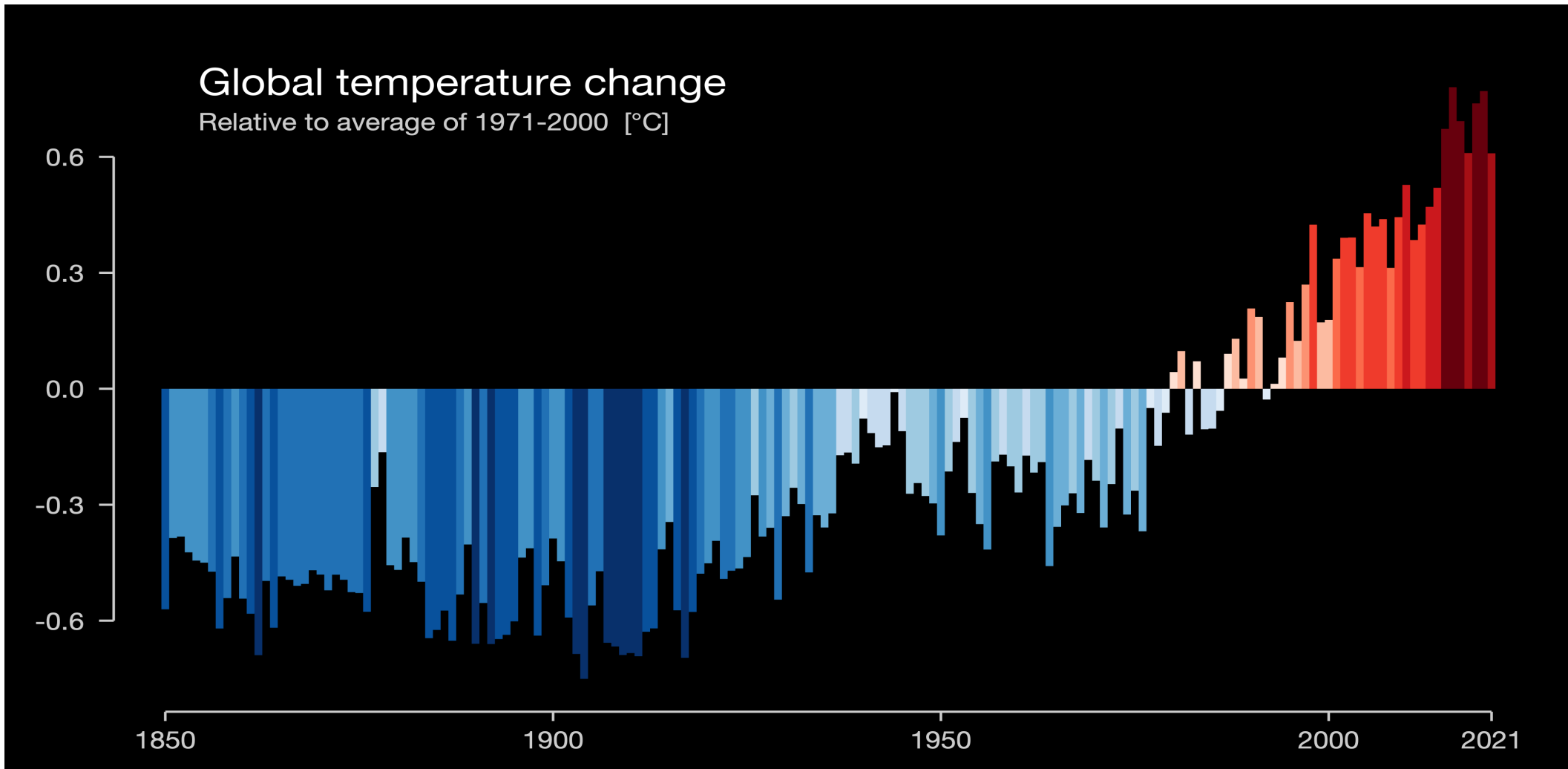
(40 M t CO<sub>2</sub>e á € 180)



Photo: M. Stegmann

# The climate crisis is obvious

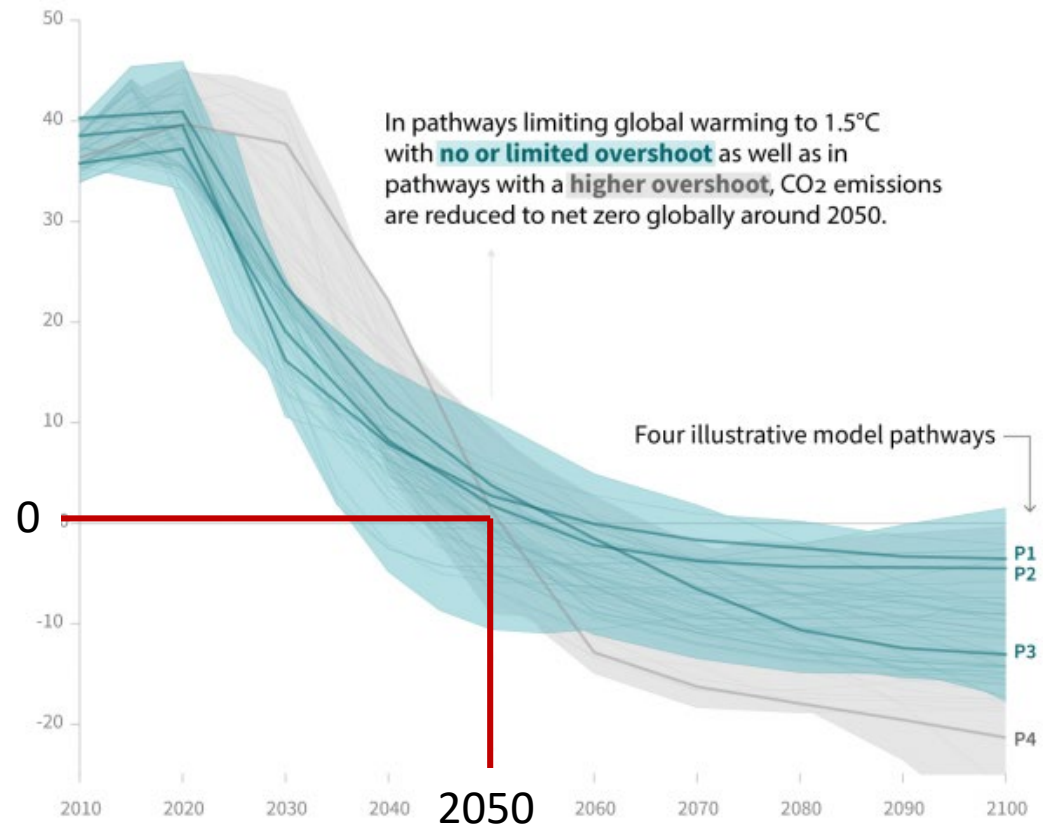
→ ...with increasing risks for food and water security, growing social breakdown, conflict and migration.



# Paris Agreement: 1.5 °C limit

## Global total net CO<sub>2</sub> emissions

Billion tonnes of CO<sub>2</sub>/yr

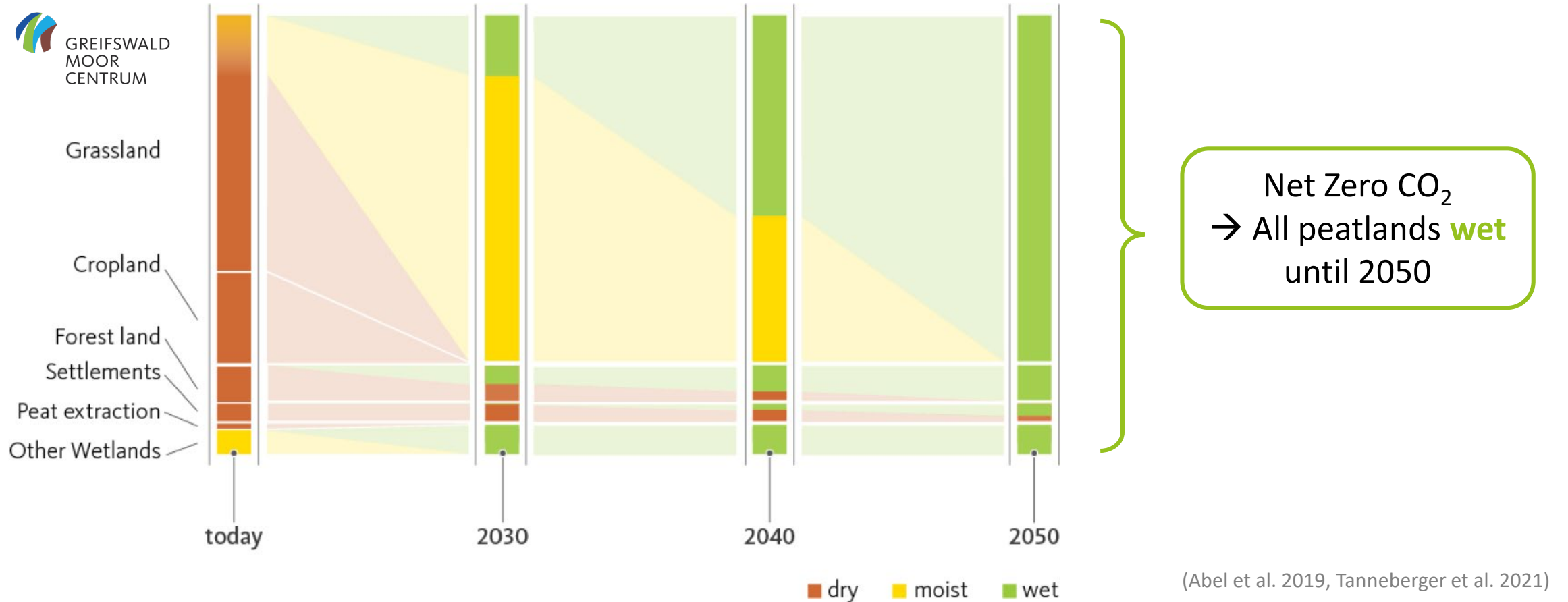


→ Net Zero CO<sub>2</sub> emissions until 2050

→ Change of perspective:

C-store = every peatland is important!

# Emission reduction pathway for peatlands in DE



→ rewetting: ca. 50,000 ha per year

Peatland rewetting efficiently mitigates CO<sub>2</sub> emissions

→ Loss of productive land?!



# Paludiculture

„*palus*“ - swamp + „*cultura*“ - cultivation

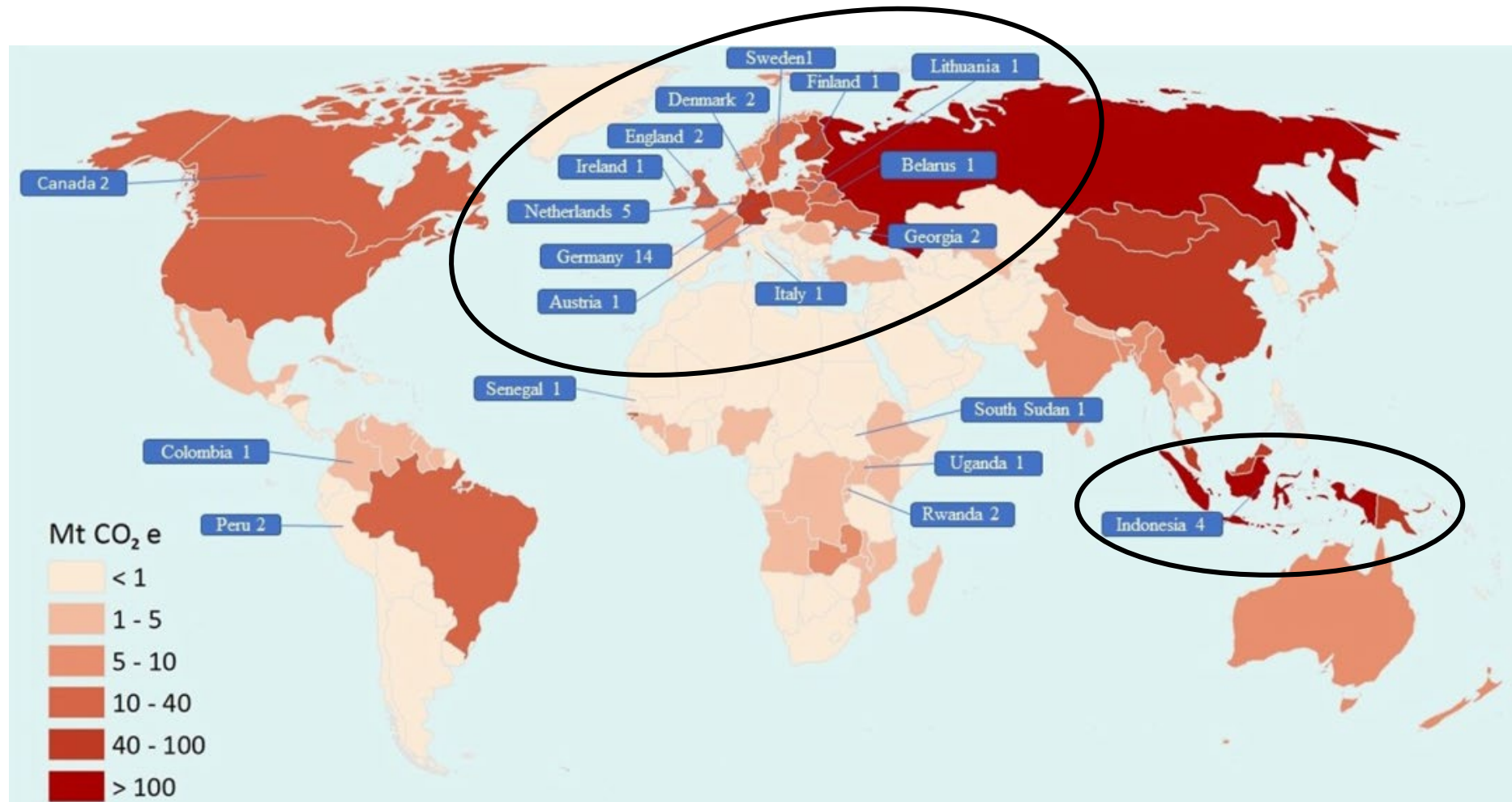
→ **productive use of wet and rewetted peatlands**

# Globally increasing interest

Europe + South-East-Asia

→ Major regions for research on paludiculture

→ Hot spots of peatland CO<sub>2</sub>e emissions



Survey on paludiculture

Answers per country

(Ziegler et al. 2021)



# Database of Potential Paludiculture Plants (DPPP)

- DPPP: **1128** entries of wetland species worldwide
  - Compilation of **~ 100** species published (440 pp.) →
  - Individual plant portraits
  - Properties and cultivation
  - Traditional and innovative utilisation options
- Assess potential + identify promising species



GREIFSWALD  
MIRE  
CENTRE

## POTENTIAL PALUDICULTURE PLANTS OF THE HOLARCTIC

Abel, S. & Kallweit, T.

Proceedings of the Greifswald Mire Centre  
04/2022



[https://www.greifswaldmoor.de/files/dokumente/GMC%20Schriften/2022\\_Abel%20&%20Kallweit\\_2022\\_DPPP\\_Holarctis.pdf](https://www.greifswaldmoor.de/files/dokumente/GMC%20Schriften/2022_Abel%20&%20Kallweit_2022_DPPP_Holarctis.pdf)

# Common examples for paludiculture

## Bogs

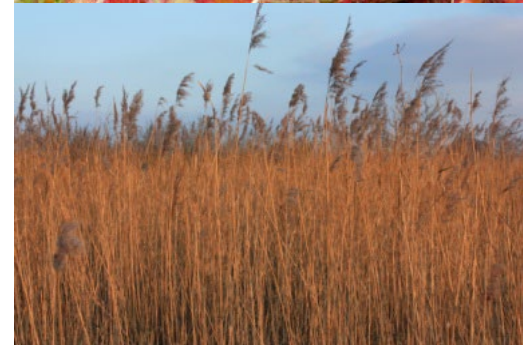
- *Sphagnum* moss
- Sundew

## Fens

- Reed
- Cattail (Typha)
- Sedges
- Reed canary grass
- Reed sweet grass
- Alder
- Willow
- Medicinal plants

Wet grassland

→ many more species suitable and knowledge need to be developed



# Wet meadows (pastures): reed canary grass, sedges, rush, ...



# Wet meadows: energetic utilisation

DE, EST, PL, NL ...

→ Direct combustion or biogas generation

## Example: heating plant Malchin /DE (since 2014)

- Round bales: 1.200 t of hay
- 800 kW boiler → 4.000 MWh per year (= 350.000 L heating oil)
- Heat for ~ 500 households, school, childcare centre

→ heterogeneous biomass + unspecific utilisation



<http://www.niedermoor-nutzen.de/>



Photo: S. Wichmann



Photo: S. Wichmann



Photo: T. Dahms

# Wet meadows: material use

BE, NL, DE, ...

## Lignocellulose → fibres

- **Foam panels** acoustic and insulation material
- **Pressed panels** insulation, cladding, interior walls, furniture panels
- **Fibre mouldings** tableware, egg cartons, packaging, flower pots, ..

→ heterogeneous biomass + unspecific utilisation



# Large-scale: wet meadows

NL, DE, PL, LIT, EST, ...

- Conservation management → Agri-environmental schemes
- Harvesting machinery available
- Often no (cost-covering) biomass use
- Outlook: low input + biodiversity synergies → larger areas, new value chains needed



Photo: S. Wichmann



Photo: I. Mirowski

# Wetland plants have unique features

- Exposed to greater forces than land plants (wind, waves)
  - **Sclerenchyma tissue**: resilient structures
  - construction material
- Roots also need oxygen under water
  - **Aerenchyma tissue**: light and open
  - insulation material
- Protected by **special ingredients**  
e.g. silicon → elasticity, high water resistance, low inflammability;  
co-absorption of e.g. germanium (phyto mining)

→ **Specific biomass for specific utilisation**



Foto: S. Wichmann



[https://www.dbu.de/123artikel35047\\_2430.html](https://www.dbu.de/123artikel35047_2430.html)

# Reed in construction

## Traditional utilisation

Wetland plants used as locally available, renewable construction material all over the world

- Thatch
- Plaster base
- Insulation panels

## New: sound absorber



**HISS REET**  
1833  
SCHÖNES AUS REET





## Innovative reed use

3D silicon nanostructure from reed leaves

→ high-performance lithium batteries

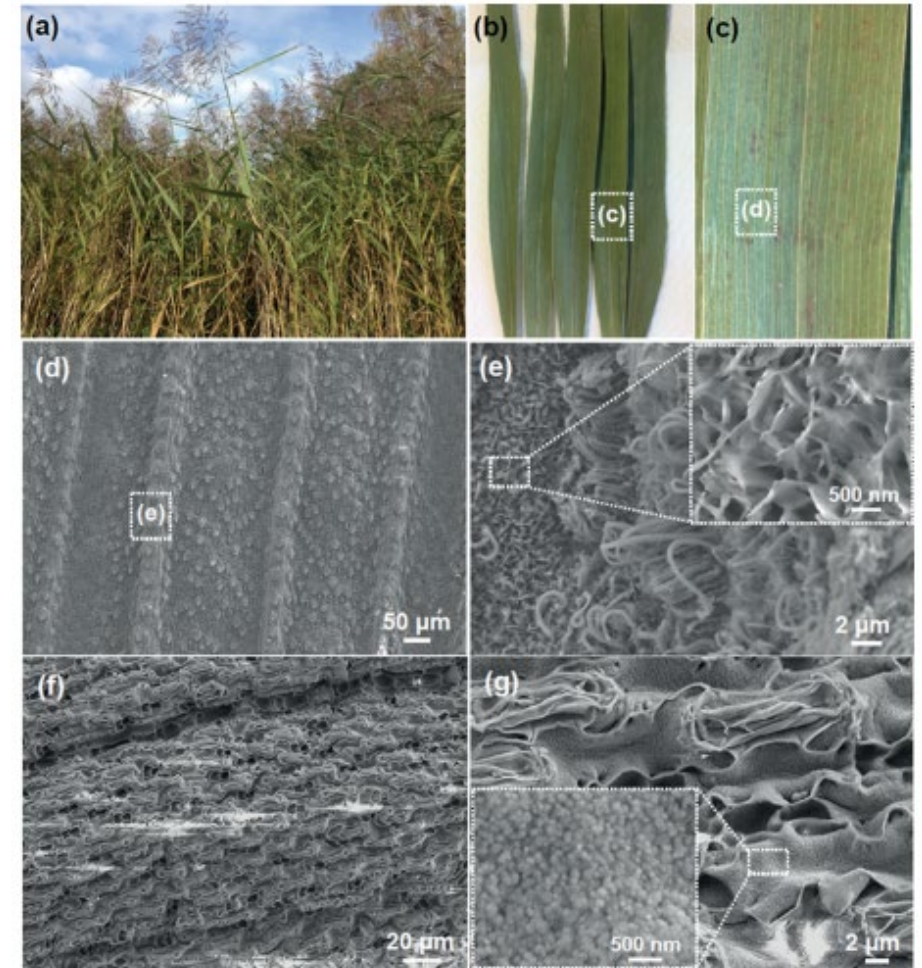
**Angewandte**  
Communications

**Anode Materials**

**Energy Storage Materials from Nature through Nanotechnology: A Sustainable Route from Reed Plants to a Silicon Anode for Lithium-Ion Batteries\*\***

*Jun Liu, Peter Kopold, Peter A. van Aken, Joachim Maier, and Yan Yu\**

International Edition: DOI: 10.1002/anie.201503150  
German Edition: DOI: 10.1002/ange.201503150

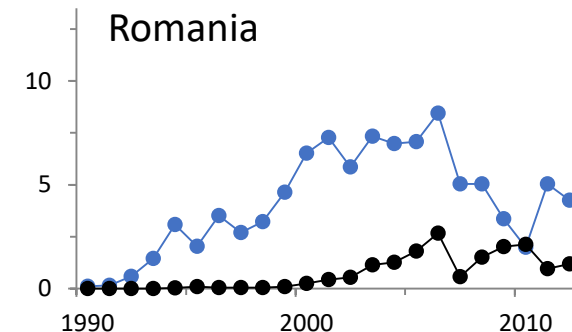
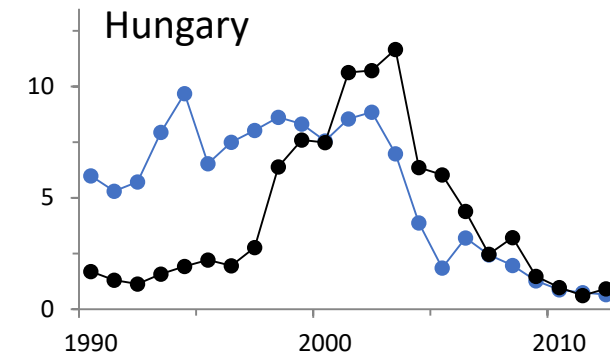
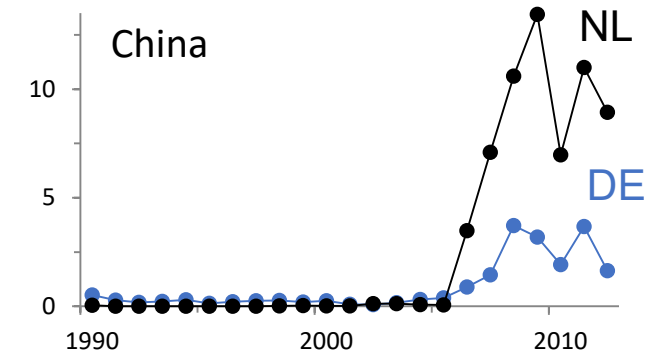


Reed demand in Europe: ca. 15 Mio bundles / year  
 NL, DE, UK, DK → import rate: 75-85%

## Exports (1990–2012)



Amount of reed / 10<sup>6</sup> kg



# Large scale: reed harvest

SE Europe, NL, PL, DE, UK, DK, LIT, F, China...

- Traditional + commercial cutting for thatch
- Harvesting machinery available + production chain established
- Globally traded commodity, but demand for regional reed
- Outlook: high economic potential + limited area demand



Photo: S. Wichmann



# Pilot stage: Typha cultivation + utilisation

NL, DE, UK, FIN, ...

→ increasing number of (mostly small) pilots

DE: ~ 10 ha pilot on former fen grassland (since 2019)



# North America: harvest of invasive *Typha*

CAN, USA

- Conservation management for wetland habitats  
→ reduce cover of *Typha*
- Mowing is one among other strategies
- Biomass utilisation to reduce management costs  
→ focus on biofuels



## Cattail Biomass to Energy:

Commercial-scale harvesting of cattail biomass for biocarbon and solid fuel

Richard E. Grosshans, IISD and Lorne Grieger, PAMI

iisd International Institute for Sustainable Development

PAMI Institut international du développement durable



Manitoba, Canada (Svedarsky et al. (2019) Mires and Peat)

Grosshans & Grieger 2015

# Typha: Wide range of high-value material use

- Load-bearing and insulating panels
- Cavity wall insulation
- Seed hairs as reinforcement for clay plaster, as filling etc.
- Further: Leaves as plaiting material, raw material for horticulture, ...

→ Specific properties + specific utilisation



Foto: Sabine Wichmann



© typha technik Naturbaustoffe



© typha technik Naturbaustoffe

# Pilot stage: Typha cultivation

NL, DE, UK, FIN, ...

- Site selection is crucial
- Fructification: high impact on quality + utilisation options
- Harvesting machinery suitable for chopped material, not yet for bundling or seed heads
- Few experience with (commercial) drying and processing



# Ready for practice: *Sphagnum* paludiculture

DE: ~ 17 ha of former bog grassland in NW Germany





# *Sphagnum* paludiculture on former bog grassland since 2011

Initial state



# *Sphagnum* paludiculture on former bog grassland since 2011

Initial state

→ site preparation + seeding



# *Sphagnum* paludiculture on former bog grassland since 2011

Initial state

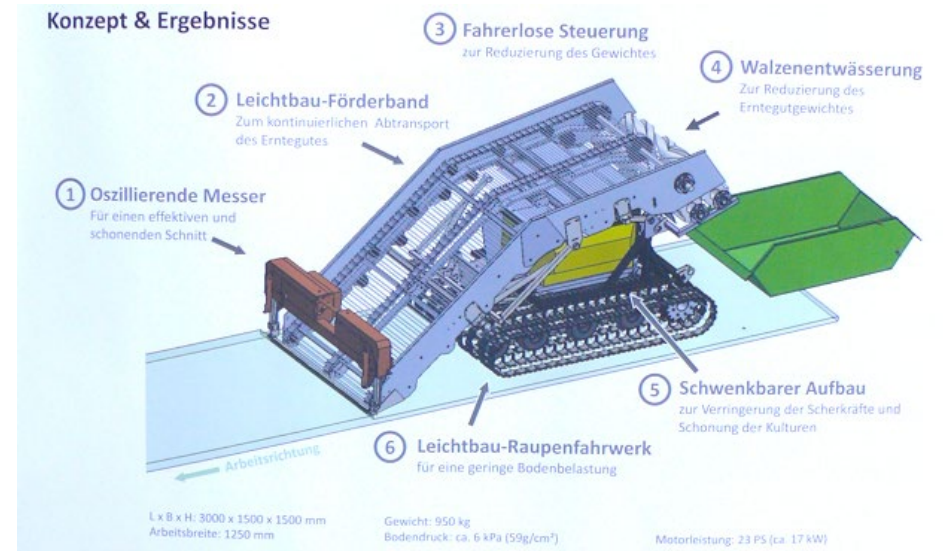
→ site preparation + seeding

→ established culture



# Large-scale harvest of cultivated *Sphagnum*

Excavator with mowing bucket; adapted and new machines





**Cultivated *Sphagnum* biomass:**

- Profitable as diaspores and for orchid cultivation
- Competitive in quality with peat, but not in price
- → 10% top up for sustainable end product needed

(Wichmann et al. 2020, Mires and Peat)

# Demonstration stage: *Sphagnum*

DE, NL, LV, LIT, UK, IRE, DK,  
S, FIN, CAN, (China) ...

- *Sphagnum* paludiculture: sustainable alternative for degraded bogs
- *Sphagnum* biomass: high-quality raw material for professional horticulture  
→ crucial to phase out fossil peat use (100%)
- Whole production chain + market developed (DE: 35,000 ha needed)
- Optimisation: site preparation, harvesting machinery, surcharge on peat-free products



# Niche markets for wetland plants

- Food

- Wild rice
- Berries

- Flavour

- Sweet grass
- Sweet gale

- Ornamental plants

- Yellow flag

- Medicinal plants

- Bog-bean
- Sundew



*Zizania aquatica*



*Vaccinium oxycoccos*



*Menyanthes trifoliata*



*Rubus chamaemorus*

# Sundew cultivation

- Medicinal plant
- Established market
- Raw material so far gathered in wild population, e.g. in Africa
- Cultivation in NW Germany (by-product) + in NE
- Spin-off Uni Greifswald:





# Paludiculture = multifold climate benefits

1) Minimise soil emissions  
(CO<sub>2</sub>, N<sub>2</sub>O)



2) Biomass replaces fossil resources  
(e.g. oil, gas, peat)



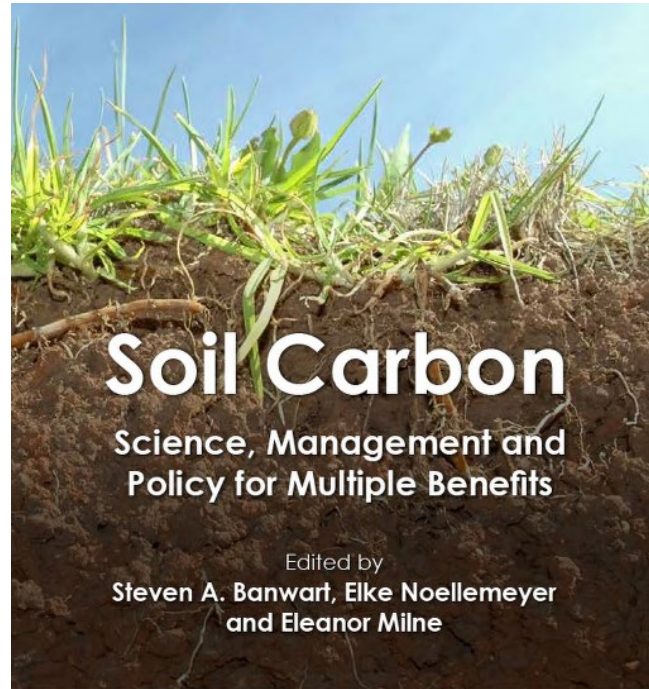
3) Carbon capture  
→ Storage in products  
(e.g. construction)



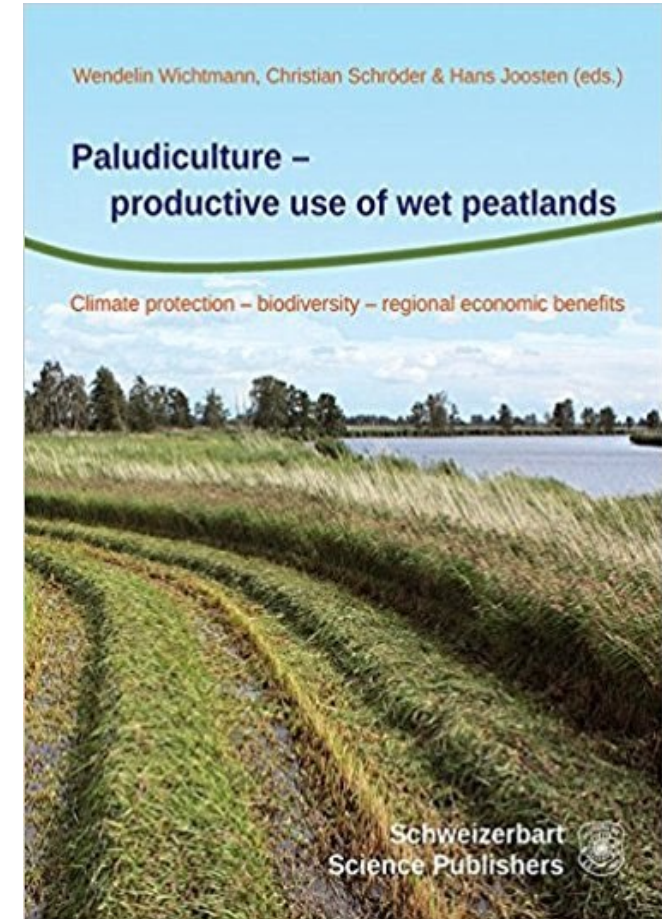
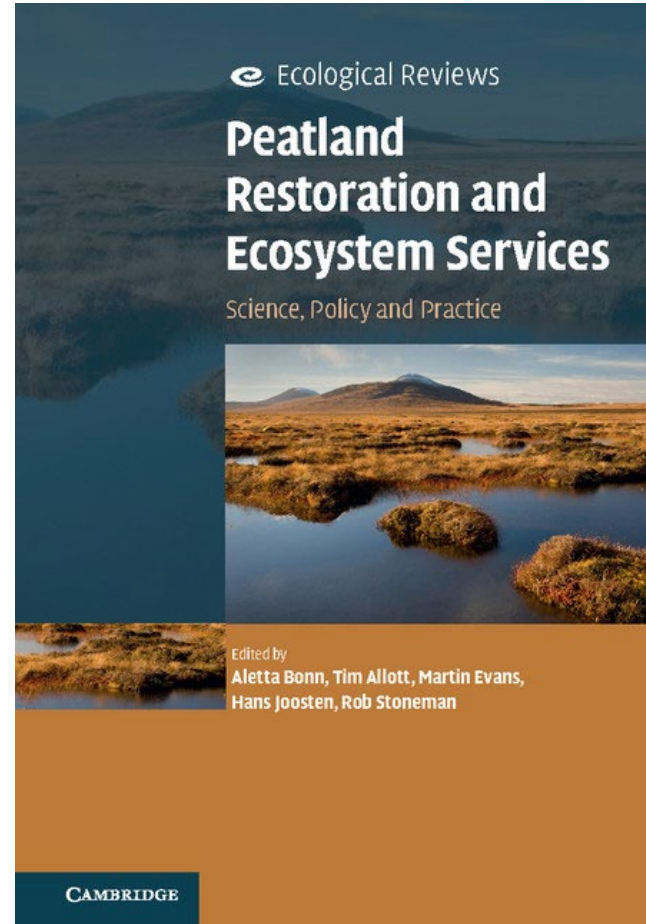
4) Carbon capture  
→ New peat formation



... sufficient knowledge available ...



SCOPE SERIES VOLUME 71





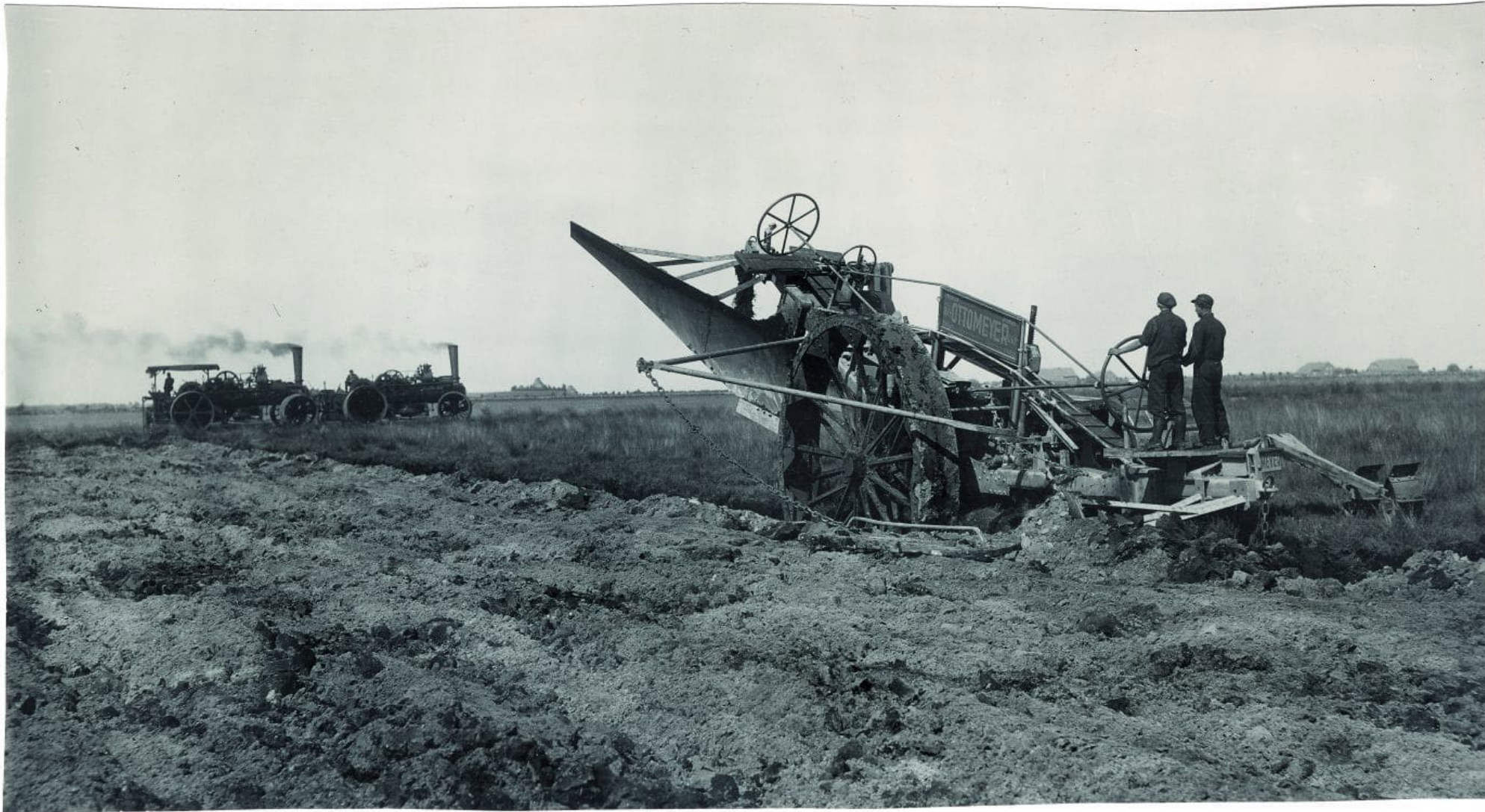
Poor  
road

# Paludiculture = paradigm shift in peatland utilisation

- 1) **Water retention** instead of drainage
- 2) **Crops and machinery** adapted to water saturated soils
- 3) Refine / develop **utilisation options + markets** for wetland biomass
- 4) Revise **general framework**: education, cooperative action, policy and regulations



# Peatland drainage and reclamation took centuries...



deep ploughing in the 1950ies (Mammut / Co. Ottomeyer ), Emsland (Germany)

<http://klasmann-deilmann.com/unternehmen/ueber-uns/geschichte/>

## New challenges – less time ... but many opportunities for action

- Binding **climate targets** for agriculture and horticulture
  - Effective **incentives** for rewetting and paludiculture
  - **Decarbonisation needs** increase demand for renewable resources
  - **Scaling-up** pilots on cultivation and biomass processing
  - **No 'one-fit-all' solution** available → develop own approaches at local /regional level
- Exchange experiences: together we will be faster



Thank you for your interest!

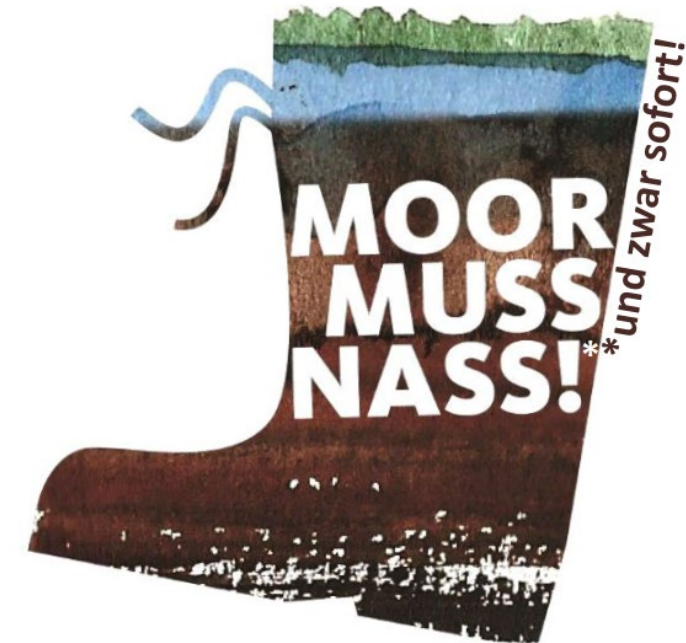


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Peatlands must be wet!

\*immediately!