Project *brief*

Thünen Institute of Forest Ecosystems

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Forest peatlands: their contribution to biodiversity and climate protection

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- **Forests are extremely important for binding carbon dioxide from the atmosphere.**
- **At high water levels, forest peatlands feature lower greenhouse gas emissions and higher specific biodiversity than drained sites.**
- **This fact must be given greater consideration in current forest management practices.**

Background and aims

In Germany, peatland protection has become the focus of political and public attention in terms of climate protection and the preservation of native biodiversity. The main focus is on drained peatlands under agricultural management. However, 15% of peatlands in Germany are forested and have received little attention, even though they are also predominantly drained and emit 3.3 million tonnes (t) of CO_2 equivalents (CO_2e) annually (UBA 2024).
The project "Forest peatlands: their contribution to biodiversity and climate protection" investigated how different forest peatland types are characterised. The aim was to demonstrate their relevance for biodiversity and climate protection and to derive silvicultural recommendations from this.
The project was carried out at the Thünen Institute of Forest Ecosystems (TI-WO) and the Eberswalde University for Sustainable Development (HNEE). Research on greenhouse gas (GHG) – emissions and water balance was conducted at the TI-WO. At the HNEE, the focus was on typifying and cataloguing the different types of forest peatlands (fig. 1), biodiversity assessments and silvicultural management options.

Approach

First, we conducted a literature review on existing GHG emission factors for forested peatlands. As these turned out to be insufficient, our research focused on specific measurements using gas exchange chambers for the three climate-relevant gases carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20) in forested peatlands. The following criteria had to be met for the inclusion of measurement results to form differentiated emission estimates:

- location within the same climate zone as Germany
- forest ecosystem on peatland with a tree cover of at least 30%
- measurement of all three relevant gases CO_2, CH_4, N_2O
- detailed site description: soil and air temperature, peatland water level, soil trophy, pH value, main tree species
- transparent method description
- measurements at least once a year or over a vegetation period with calculation of annual balances.

The GHG balance was calculated in accordance with IPCC (2014), taking into account the following components:

- GHG balance of the soil system (including ground vegetation)
- carbon stock change in the tree stand
- discharge of dissolved organic carbon (DOC)
- CH_4 emissions from ditches.

IPCC default values were used for the latter two.

Figure 1: Wet alder stand as a possible type of forested peatland (Photo: Julian Gärtner)

Key findings

For the soil system component, we compiled a total of 42 GHG balances from gas exchange chamber measurements. It should be emphasised that this is a small data set for the derivation of generally valid and differentiated findings.
Our statistical analyses show a significant dependence of CO_2 emissions on the site parameters: air temperature, peatland water level, nutrient and acid-base ratios in the soil. We observed that CO_2 emissions increase with increasing temperature and decreasing peatland water level as well as with higher soil trophy and higher pH values. CH_4 emissions are negligible at water levels lower than approx. 20 cm below

peatland surface; they only increase above this level. Significant dependencies on one of the environmental variables mentioned above could not be demonstrated. The analyses also show that relevant N_2O emissions only occur at water levels deeper than about ten centimetres below peatland surface and then scatter considerably. A dependency on soil trophy and the main tree species was also demonstrated. It should be emphasised that high emissions mainly occur at eutrophic sites with alders capable of fixing atmospheric nitrogen.

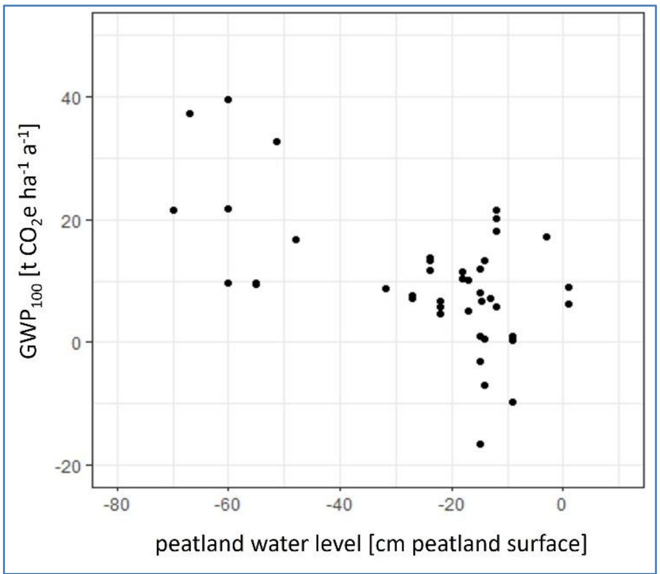

Figure 2: Distribution of the 42 researched data sets on GHG balances of the soil system of forested peatland sites along the mean peatland water level (Source: Protze et al. in press)

The GHG balance of the soil system, expressed as GWP_{100} (Global Warming Potential as the sum of the three relevant gases over a time horizon of 100 years), primarily reflects CO_2 emissions, which have the greatest impact. In our calculations, this balance ranges from -16.5 to 39.5 t CO_2e per hectare (ha) per year (a). This ranges from GHG sinks (negative sign) to strong GHG sources (positive sign). The data set shown in figure 2 demonstrates a clear difference: forested peatlands with near-surface water levels no deeper than 20 cm below peatland surface in the annual median emit 5.6 t CO_2e per hectare per year, while more deeply drained areas emit 14.3 t. If carbon sequestration through wood growth (according to Dunger et al. 2023) is added to the GHG balance of the soil system, DOC and CH_4 emissions, wet peatland forests overall emerge as carbon sinks (see table 1).

Table 1: GHG balance illustrated for three peatland forest types as example (Source: Protze et al. in press)

Peatland forest type	**Components GHG balance** [t CO_2e ha^{-1} a^{-1}]			
	GWP_{100} soil system	DOC-dis-charge	CH_4 from ditches	C seques-tration wood growth
(1) wet alder stand	5,6	0,88	-	- 8,3
(7) very moist to moist pine stand	5,6	1,14	0,15	- 4,1
(14) moist to moderately moist spruce stand	14,3	1,14	0,15	- 12,5

Conclusion

At high water levels, peatland forests feature lower greenhouse gas emissions than drained sites. The project partner HNEE was able to demonstrate higher specific biodiversity in wet locations. For these reasons, forestry operations on peatland sites should be carried out with high water levels. However, this is not always feasible or would at least involve significantly higher costs, such as the purchase of cable crane technology for soil-conserving cultivation.
Due to the general methodological difficulties and the comparatively small data set, the newly derived emission groups should be regarded as estimates and not as robust emission factors. For robust factors and further differentiation (e.g. according to soil nutrient status), additional measurement data is required, such as from the TI-WO's peatland soil monitoring for the forest (MoMoK-Wald).

Cited literature:

Dunger et al. (2023). Handlungsempfehlungen und Baumarteneignung auf organischen Böden. Ergebnisse aus dem Projekt MoorWald, Thünen Working Paper, 221.

IPCC (2014). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.

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Further Information

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Publications

Protze D, Schulz C, Hilgenfeld M, Spathelf P, Dunger S, Wellbrock N, Luthardt V (in press) Waldmoore: ihr Beitrag für den Biodiversitäts- und Klimaschutz, BfN-Schriften, Bonn

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