Briefing paper

Peatlands in Brazil – the most carbon dense ecosystem under threat

What do we know about Brazilian Peatlands

Some 20-30 % of the world's peatlands are found in the Tropics. Brazil is the tropical country with the largest peatland extend totalling 226,000 km² (2.6% of the area of Brazil) based on best estimates, of which about 17,000 km² are with peat dominant and another 209,000 km² with peat occurring in patches [1]. Brazilian Amazonia, e.g. the Rio Negro basin and along river valleys, is expected to be a peatland hotspot with estimated 132,000 – 171,000 km² of peatlands[1–3]. They also occur frequently in valleys and mountains in the Cerrado and in the Atlantic Forest biome and peatlands cover plains over large parts of the Brazilian coast (Table 1, Figure 1).

Land use on organic soils and greenhouse gas emissions

Peatlands are the carbon densest terrestrial ecosystem. In the Tropics they store 152-288 Gt carbon, which is 4-8 times the total global anthropogenic greenhouse emission for 2023 [4,5]. In Brazil, Silva et al. (2024) estimated the C stock in peatlands at 7 Gt, a value lower than the extrapolated 39 Gt C UN estimate [6]. According to the Global Peatland Database, 3,540 km² of organic soils in Brazil are currently under land use, leading to greenhouse gas (GHG) emissions of 18 Mt $CO_{2\text{-eq}}$. This number may be a large underestimate given the recent extreme droughts, heat waves and fires in Amazonia and the Cerrado, that affect all wetlands, leading to rapid peatland degradation and GHG emissions. Brazil does not report carbon emissions from land use on organic soils despite of reported land use on 3,000 km² of organic soils for 2010 [7,8]. The need for a monitoring of land use on organic soils is evident. Unaccounted GHG emissions result from, e.g. from peatland drainage, peat fires, from agriculture and urban encroachment, amongst others.

Table 1: Area of organic soils by Brazilian biomes in km², GPD – Global Peatland Map 2.0.

Biome	Peat soils dominant (km²)	Peat soils in patches (km²)	Total (km²)
Amazonia	212	170,930	171,142
Pantanal	183	18,375	18,558
Cerrado	3,696	14,140	17,836
Atlantic forest	12,079	4,121	16,200
Pampa	1,033	1,253	2,286
Caatinga	35	0	35
Total	**17,238**	**208,819**	**226,057**

Peatlands across Brazil

In Brazilian **Amazonia** peatlands are expected to occur along rivers and in interfluvial depressions. About 80,000 km² of palm swamp forest are suspected and herbaceous peatlands occur in interfluvial areas especially in the Rio Negro region. Information on these peatlands is very scarce, especially in contrast to the Peruvian Amazon, where over a decade of peatland research provides a good peatland picture [9]. Thus, it is currently very challenging to assess the impacts of extreme droughts and wildfires on peatlands in Brazilian Amazonia. It is likely that they are affected and degraded, too. Carbon stored in the soil as organic carbon is lost. The potentially very large peatland areas and the current devastating change in the amazon system underline **a high urgency for research to understand Amazonian peatlands in Brazil and the impacts of climate change and deforestation on them.**

In the central Brazilian **Cerrado** savannas, peatlands occur in rather narrow valleys mostly as part of headwater wetlands that form an extensive biome-wide wetland network. They also occur in the

Peat, peatlands, organic soils and wetlands

Peat (Portuguese: *turfa*) is partially decomposed organic material that sedentarily accumulated due to permanent water saturation of the soil. **Peatlands** (pt: *turfeiras*) are areas with an accumulated peat layer at the surface. Depending on the definition, peat has at least 12–18% organic carbon by weight in the uppermost 20–50 cm of the soil [22]. Peat soils, also referenced as Histosols, are part of organic soil classes. Since **organic soils** include soils with organic carbon content lower than 12–18%, not all organic soils are peats. In Brazil, peat soils fall under the organic soil sub-classes "thiomorfic" (pt: *tiomórfico*), "folic" (pt: *fólico*) or "humic" (pt: *háplico*), but they can be found in other soil classes, if the organic surface horizon is shallower than 40 cm [28]. **Wetlands** are areas which are temporarily or permanently inundated or water-saturated with vegetation adapted to saturated soil conditions. All natural peatlands are permanent wetlands [27].

depressions of the planation surfaces of the Serra do Espinhaço mountains, headwaters of the rivers of the great basins of eastern Brazil [10]. This Cerrado wetland network supplies 7 of the 12 biggest river systems in Brazil and is essential for constant river water flows also during the dry season[11]. Peatlands in wetland complexes function as water buffers that store water during the wet season and slowly release it during the dry season, playing an important role in the country's water cycle. 13% of the total carbon (3.2 Gt) stored in the Cerrado may be stored below-ground in its peatlands, which cover less than 1% of the area. Vegetation is open (palm) swamp savanna (locally known as *Veredas*) or gallery forest. Peatland distribution is only partially mapped and described with a likely large underestimation of extent [12].

The Cerrado is a hotspot of deforestation for industrial agriculture (soy, corn, coffee, sugar cane, pastures, etc) and forest plantations (pulp wood and coal production) that even exceeds the rate of deforestation in Amazonia. More than 50% of the natural vegetation in the Cerrado is already lost [13]. This drastic land use changes lead to direct and indirect negative impacts on the peatlands and wetlands. Groundwater levels decrease, leaving drying peatlands and wetlands exposed and vulnerable to frequent fires - especially in the tropics. Losses of wetlands and peatlands can happen quickly over periods of a few years only. In addition, deforestation in Amazonia and climate change are leading to longer and hotter dry seasons in the Cerrado and Pantanal, which are exacerbating droughts [14]. Very few studies assess wetland losses following degradation through industrial agriculture in the catchments [3,10]. **Mapping and monitoring, and understanding the hydrology of peatlands is an urgent need** to enable an assessment of the ongoing degradation and wetland/ peatland losses and allow adequate protective measures.

Along the entire **coast of Brazil** (**Atlantic Forest and Pampa biomes, Amazone biome, Caatinga biome)** peatlands are distributed at plains and in estuaries of **coastal lowlands**. Peat forests and open herbaceous peatland occur. Due to past explorations, knowledge on peatland distribution is better for the coastal regions of the Atlantic Forest biome and Pampa, i.e. in the South. In southern Brazil, coastal peatlands are drained and used for agriculture or directly lost to encroachment of urbanization. There are accounts of peat fires from coastal plains in northern Brazil (state of Amapá). In general, peatland types are poorly known and land use on peatlands is not assessed.

There is great uncertainty about the extent of organic soils and peat in **the Pantanal**. Natural seasonal water table fluctuations of several meters and strong water dynamics may favour or inhibit peat accumulation depending on the location. Floating mats with a thickness of more than 1 m may prevail over larger areas. Peat/ organic soil information is generally scarce despite a few confirmed wetlands

with organic soil, e.g. in the northern Pantanal. During the extreme fires in 2020, which burned 2/3 of the Pantanal, accounts of peat fires occurred [15].

Mountain and highland peatlands occur in the interior of the Atlantic Forest, Cerrado and Pampa biomes in mountain valleys and depressions. The Espinhaço mountain range in Minas Gerais is the only peatland region (25,400 ha) with continuous systematic peatland research in Brazil [3,16]. Peatlands are partially degrading through pastures and drying due to more frequent droughts. Urban and infrastructure development is probably posing a risk to peatlands and wetlands in general, too. Also, in the Brazilian part of the Guiana Shield peatlands can be expected, as suggested by the presence of peat mosses on the Pico da Neblina and the reported peatlands in the Guiana Highlands in neighbouring countries [9]. In general, however, little is known about the carbon stocks, biodiversity, ecosystem services, conservation status and potential threats to Brazil's mountain peatlands.

Pictures 1: Left - herbaceous mountain peatland, Serra Espinhaço Meridional, credit: Alexandre Silva; right – palm swamp savanna, Cerrado; credit: Felix Beer.

Legal status of peatlands in Brazil (adapted from Beer et al. 2024)

Brazil's environmental legislation is considered ineffective and insufficient for wetland protection in general [17,18]. The wetland definitions in the federal Brazilian Native Vegetation Protection (LPVN) Law (12,651, May 2012) – the most important Brazilian nature conservation law – excludes e.g., areas of temporary or permanent water saturation, the latter encompassing peatlands [18,19]. Neither peatlands, peat soils nor organic soils are explicitly mentioned or protected by environmental law in Brazil. Consequently, activities with negative impacts such as cattle grazing and extraction of water for domestic purposes remain allowed in various wetland types. Further problematic regulations concern the delimitation of permanent protection areas (PPAs), the restoration of PPAs, or the monitoring of the protection of small streams and specific wetland types (e.g. swamp savannas with peat) [17,18]. Hence, the evident general need for a more effective and inclusive wetland protection aligned with the Ramsar Convention and including peatlands by the LPVN and through improved management would require a set of measures including clearer, consistent definitions of all wetland types. To identify wetlands in the field the criterion of a minimum water table at the end of the wet season is recommended [17,18,20]. In the frame of improved wetland type definitions, it is recommended to include peatlands into the LPVN and state environmental laws as a distinct wetland type due to their outstanding role in carbon storage and for water regulation. Although existing peatland definitions include organic soils with organic carbon contents higher 12 to 18%, from a climate perspective, peaty soils with an organic carbon content between 8 and 18% should be protected equally since GHG emissions upon degradation can be as high as from peat soils [21]. The catchments are hydrologically essential for the water supply to wetland complexes, in which peatlands are embedded. In order to

adequately protect wetlands by ensuring sufficient groundwater recharge in their catchments environmental legislation should reflected that hydrological dependency, e.g., through a landscape-based approach, and ideally regulate land-use in the catchment with regards to its potential negative impacts on the water balance [17].

Knowledge gaps and need for action

- The extent of **Brazil's peatland area** is subject to **large uncertainties** [6]. Other sources than the most recent numbers of the Global Peatland Map 2.0 report extents of organic soils in Brazil between 55,000 km² and 312,000 km² [3,8,22–25]. Most of the unexplored area lies within Amazonia [22,23,26] but also the Cerrado, the Pantanal and the coastal peatlands lack mapping and monitoring.
- **Further information on all aspects of peatlands is lacking** in all parts of Brazil, including information on peatland types, ecology, hydrology, carbon storage and cycling. Only in the Serra do Espinhaço (Central East Brazil), have peatlands been studied and monitored in more than two decades long ecological research (LTER turf) [3,15].
- The (degradation) status of most peatlands is almost unknow. A monitoring/ an assessment at national or federal state level of land use on organic soils does not yet exist and is needed. It is likely that current and past degradation through land use on organic soils is happening at relevant scales and pace but remains unaccounted for.
- **Missing knowledge:** The "peatland concept" is only known to a small research community in Brazil and needs more visibility. Initiatives that promote peatlands to the society (e.g. schools, (traditional/indigenous) communities, environmental managers and politicians) such as LTER turf should be encouraged with public and private funding. The contexts of better wetland protection and water security should be considered.
- **Carbon emissions** from land use on organic soils in Brazil are not known and not reported by the Brazilian government to the UNFCCC [7]. Greenhouse gas emission measurements and data for land use on wetlands/ peatlands in Brazil is almost completely lacking.
- An assessment of the **potential and real impacts of the climate crisis on peatlands** and other wetlands in Brazil does not exist and is urgently needed.
- Peatland/ organic soils need better protection by Brazilian (environmental/ climate) law. **Peatland management strategies** that aim at keeping peatlands wet or which aim rewetting and restoring them should be developed and implemented.

Pictures 2: Left and bottom central: area affected by peat fires; upper central and right: drainage & agriculture; credit: Felix Beer.

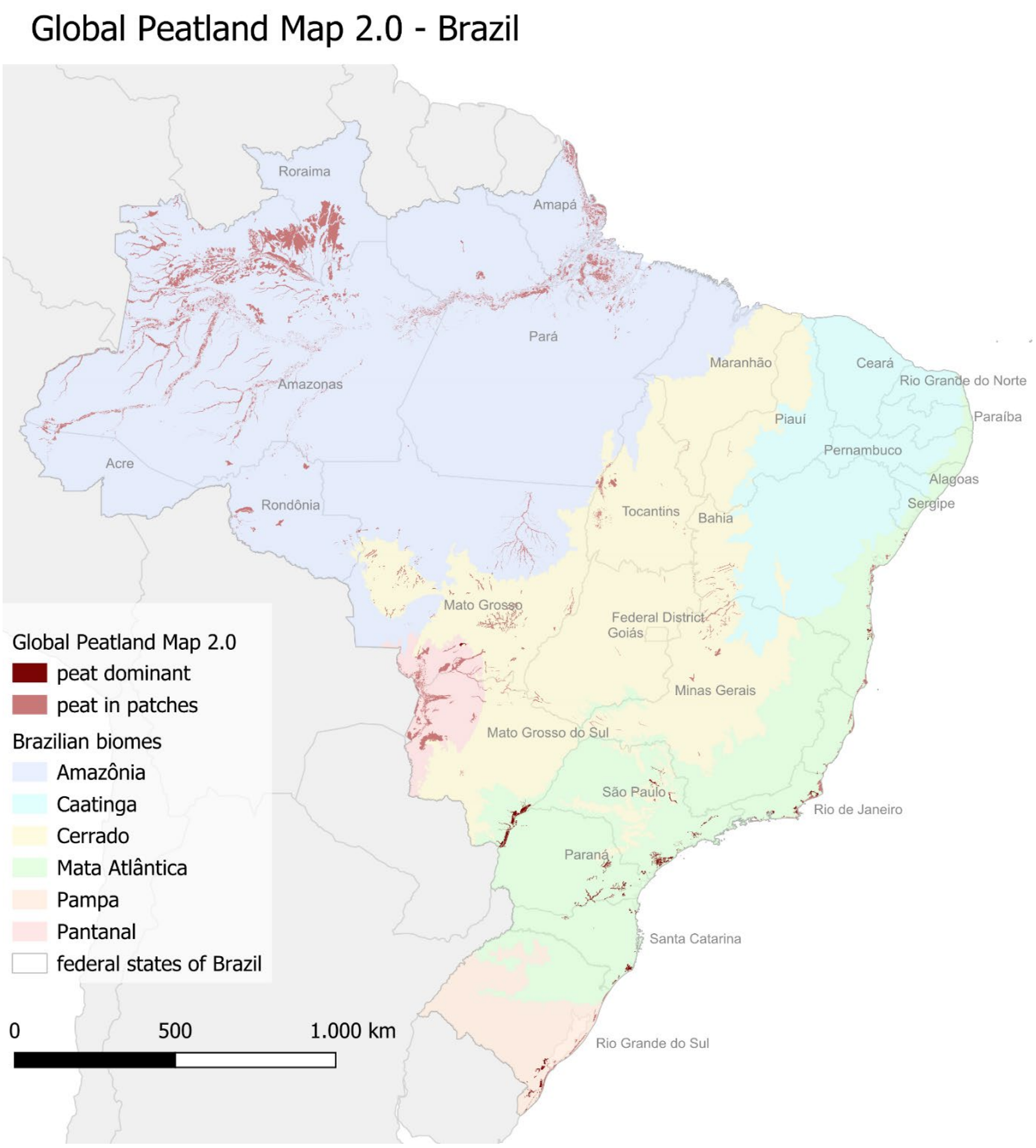

Figure 1: Peatland map of Brazil (GPD 2023). Due to the scale, 253 km² of peatlands in Serra do Espinhaço (Silva et al., 2024) are not shown.

Further reading

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