

Geospatial Aspects of Peatland Size and Regional Climate Trajectories

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Discussion of peatlands and their capacity to exchange and store carbon, and the potential for peatland-climate feedbacks, typically begins with noting the very large size of the peatland C pool. Although it is clear that peatlands hold a significant portion of the world's total land C, the true amount of peatland C is somewhat loosely constrained (230-450 Pg C) and, in spite of global maps of wetlands and soil carbon, the geographical distribution of peat C within many regions remains poorly known. Within a region, climate, topography, and substrate interact to produce a diverse distribution of large and small peatlands. Peatland size can affect groundwater hydrology, the proportional area of ecotone and edge effects, the potential for anthropogenic influence, and forest-peatland wildfire movements. Detailed peatland inventories (at least 0.1 km² resolution) from the southern Mackenzie River Basin and the West Siberia Lowland, indicate that large peatlands (95th percentile) can contribute a large component of total peatland landcover (53 and 73%), whereas small peatlands (25th percentile) contribute less (1.3 and 0.5%, respectively). Particularly when size covaries with peat depth and C storage, size distribution may be important in identifying sites and regions that are directly and indirectly sensitive to climate variation and change. Forecasts of future climate show important regional differences in overall amplified northern warming. This region-specificity, particularly differences in the seasonality of warming, is relevant to the hemispheric distribution of northern peatland C.

Geospatial Challenges Towards the Quantitative Understanding of Peatland Carbon Dynamics Across Multiple Scales

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It is widely recognised that peatlands play a crucial role in the global carbon cycle. However, large uncertainties remain regarding the strength of their functions as carbon storages and sources or sinks of carbonaceous trace gases or laterally transported dissolved or particulate organic matter. In addition to the considerable gaps in our mechanistic understanding of carbon cycle processes in peatlands and relevant metrological difficulties (Becker et al., 2008), geospatial problems on multiple scales are major causes of uncertainty. Peatland ecosystems are typically characterized by pronounced microtopography and vegetation patterns on the scale of 0.1 m to 10 m, which can be randomly or regularly distributed, and additionally by hydrological and biogeochemical gradients across the peatlands, on the scale of 100 m to 10 km. Important carbon cycle processes, e.g., methane emission, can be concentrated on

small-sized “hotspots” whose importance can only be quantified accurately using geospatial information of very high resolution (Krankinal et al., 2008). This pronounced within-ecosystem heterogeneity of peatlands has to be considered for unbiased quantification of biogeochemical processes on the ecosystem scale. This is important not only for plot-scale investigations that have to be extrapolated to the ecosystem scale (e.g., closed chamber gas flux measurements) but also for ecosystem-scale measurements that integrate over the micro-scale heterogeneity (e.g., eddy covariance flux measurements) and likewise for ecosystem modeling. Extrapolating knowledge derived at single peatland investigation sites to the regional scale (10 km to 1000 km) is complicated by the considerable heterogeneity between different peatland objects related to different geological and geomorphological situations and climatic gradients. On continental and global scales, additional uncertainty is added due to the coarse resolution of the available categorical maps and inconsistent peatland definitions and mapping approaches of different nations and/or different scientific disciplines (Kutzbach et al., 2007). For a robust and meaningful integration of peatland dynamics into global climate and carbon cycle models, we have to comprehensively address the relevant geospatial challenges hampering our quantitative understanding of peatland processes across multiple scales today.

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Spatial and Dynamic Analyses of Biogeochemical Cycling in UK Peatland Carbon Catchments

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The potential for strong biogeochemical feedbacks between the biosphere and atmosphere to determine the earth’s future climate is now widely recognised (Bardgett et al., 2008). Understanding the strength of relationships between plant ecology and soil biogeochemistry offers a means to test hypotheses and make predictions about the impacts of local and global change on ecosystem functions (Ostle et al., 2009). Peatlands are a globally important and potentially vulnerable biome containing a range of uniquely adapted biodiversity that regulates biogeochemical cycles of carbon, hydrology and energy fluxes. The spatial distribution and abundance of vegetation types across the peatland landscape is influenced by climatic and topographical conditions (McNamara et al., 2008) and, in some instances, by interactions with grazers and human management (Ward et al., 2007). In this work we are attempting an interdisciplinary research study into the relationships between peatland vegetation, soil microbes, soil C accumulation, and ecosystem greenhouse gas (CO₂, CH₄) emissions. In this presentation we will demonstrate how interdisciplinary research is being used at the Moorhouse CEH Carbon Catchment to obtain spatially explicit peatland

vegetation, peat ¹⁴C accumulation rates, peat carbon content, microbial diversity, and greenhouse gas flux data.

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The Role of Tropical Peatlands in Carbon Storage and Carbon Cycling

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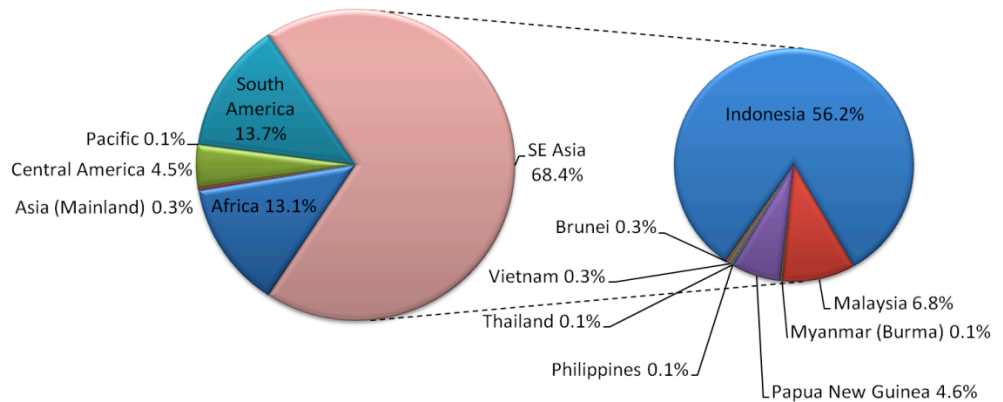
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Peatlands are important terrestrial C stores and vital components of global C soil-atmosphere exchange processes. They have their greatest extent in boreal and temperate zones, but tropical peatlands also make a significant contribution to C storage. Despite increasing interest in the role played by peatlands in the tropical C cycle and the impacts of recent land use changes and fire (Hooijer et al., 2006; Jauhiainen et al., 2008; Page et al., 2002), there have been limited reviews of their role in C storage. Accurate inventory is important in order to (a) determine the size of the C pool; (b) estimate the scale of transfers of peat-derived greenhouse gases to the atmosphere resulting from peatland disturbance; and (c) predict future trends

under the influence of climate change. We assessed information on tropical peatland area, volume, and C content in order to provide best estimates of these and extent of variation.

Tropical peatland area is 368,501 km² (range 333,871-418,149 km², ~10% of global peatland

area) with 68% in SE Asia; peat volume is 1300 Gm³ (range 950-1731 Gm³, ~20% of global volume), with 94% in SE Asia. The tropical peatland C pool is estimated at 65 Gt (range 42-95



Pie chart showing the best estimate values of tropical peatland area both globally and within Southeast Asia. The total area is 368,501 km² and the percentages in both parts are of this total.

Gt, ~15-20% of global peat C pool), with 94% in SE Asia. Indonesia holds the largest share (52 Gt), followed by Malaysia (9 Gt). The pre-disturbance peat-land sink in SE Asia is estimated at ~20 Mt C yr⁻¹ (~20% of global sink) but land use changes and fire result in a current annual loss of C equivalent to ~6% of global fossil fuel emissions. Improved understanding of the spatial extent and magnitude of the tropical peatland C store is essential given the scale of these emissions and the role these peatlands could play in C offset and trading agreements.

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Multi-Scale Influences of Wildfire and Peatland Carbon Storage

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Wildfire is the dominant natural disturbance in peatland ecosystems (Turetsky et al. 2002). Not only do wildfires directly impact regional peatland carbon stocks through peat combustion, but they can also alter the magnitude and direction of peatland carbon exchange through indirect effects on post-fire biotic (Benscoter and Vitt 2008) and abiotic conditions (Zoltai et al. 1998). By removing the living vegetation and altering microhabitat conditions, wildfire resets the successional sequence. Coupling of peatland vegetation structure and carbon storage ability results in concomitant functional change through the successional trajectory (Wieder et al. 2009), the shape and duration of which is largely controlled by fire severity. However, the relationship between wildfire and peatlands is not unidirectional. The soil conditions, vegetation structure, and distribution of peatland landforms can influence patterns of wildfire occurrence and severity from local to landscape scales. Through these cross-scale, multi-directional feedbacks, peatlands and wildfire interact to control regional carbon dynamics. Understanding these complex feedbacks has become increasingly important, as future climatic change is projected to increase the frequency and severity of wildfires, placing peatlands and their carbon stocks at risk.

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