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THE CARBON BALANCE OF TROPICAL PEATLANDS: A GLOBAL PERSPECTIVE

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SUMMARY

Tropical peatlands are some of the planet's most carbon-dense ecosystems, with a substantial carbon store of ~89 Gt, equivalent to ~20% of that stored in tropical/sub-tropical vegetation. Until recent times, climatic and associated hydrological changes were the main influences on carbon storage rates, but the last two decades have seen an acceleration of anthropogenic impacts. This paper reviews the location, extent and magnitude of the carbon storage role of tropical peatlands and assesses, on a continental scale, what proportion of the tropical peatland carbon pool is vulnerable to short-term loss as a result of anthropogenic activities.

KEY WORDS: tropical peatland, peatland area, carbon store, anthropogenic disturbance

INTRODUCTION

Peatlands are important terrestrial carbon stores and vital components of global carbon soil-atmosphere exchange processes. In this regard, tropical peatlands, which occur on the Asian, African and American continents, are particularly important since on an area basis they are some of the planet's most carbon-dense ecosystems, although knowledge of their true extent is still uncertain. There is growing recognition of the importance of carbon storage in, and carbon gas emissions from, tropical peatlands and their role in global environmental change processes, since degradation of tropical peatlands leads to release of stored carbon and a reduction in the size of their carbon pools (Page *et al.*, 2002, 2011a; Hooijer *et al.*, 2010, 2012; Jauhiainen *et al*., 2012).

This paper evaluates the status of tropical peatlands in regional and global peatland carbon pools and then assesses the likely current status of tropical peatlands on a regional (continental/sub-continental) scale in order to provide a basis for estimating the scale of transfers of peat-derived carbon to the atmosphere resulting from land use change.

MATERIAL AND METHODS

The available information on tropical peatland area, volume and carbon content were reviewed in order to determine their best estimates and ranges of variation (see Page *et al*., 2011a for full details). We defined peat as the surface layer of soil, consisting mostly of partially decomposed vegetation, with an organic content of at least 65% in a minimum thickness of 30 cm. We attempted to remove the areas of non-peat organic soils (i.e. non-peat Histosols) from our assessment. We found a dearth of reliable data on the thickness of tropical peat, thus for many countries we applied a default, conservative mean value of 0.5 m. Data on peat bulk density and percentage carbon content were also lacking and in the absence of sufficient information across the tropics we used a single composite value of 0.09 g cm^{-3} for peat bulk density and a value of 56 ± 3% for peat carbon content (Page *et al*., 2004).

In order to assess the likely scale anthropogenic activities on tropical peatlands, we undertook an assessment of the extent and nature of anthropogenic activities on tropical peatlands for the three main continental land masses with extensive tropical peatland carbon pools, namely Southeast Asia, South America and Africa. Information on the extent of peatland disturbance for Southeast Asia was derived from Miettinen and Liew (2010), Miettinen *et al*. (2011, 2012) and our own personal observations, while for South America and Africa we derived information from Joosten (2010), combined again with our own observations.

RESULTS

The values for peatland area and carbon store are presented as ‘best estimates’ (see Page *et al*. (2011a) for more detailed explanation). The largest area of tropical peatland is in Southeast Asia (247,778 km^2; 56%), followed by South America (107,486 km^2; 24%) and Africa (55,860 km^2; 13%) (Tables 1 and 2).The total tropical peat carbon pool is in the range 82-92 Gt with a best estimate of 89 Gt. The largest carbon store is in Southeast Asia (69 Gt, 77% of the best estimate total), followed by South America (10 Gt; 11%) and Africa (7 Gt; 8%) (Table 2). Within Southeast Asia, Indonesia has by far the largest share of the peatland carbon pool (57 Gt, 65%), followed by Malaysia (9 Gt, 10%).

The tropical peat carbon pool is between 14 and 19% of the global peat carbon pool, to which Southeast Asia contributes 11 to 14%. Peatland in Indonesia alone stores 9 to 11% of this global pool, while tropical peatlands in South America contribute around 3% and those in Africa around 1% (Page *et al*., 2011a) (Table 2). Together, the tropical peatlands of Southeast Asia, South America and Africa comprise 93% of the total tropical peatland area and 97% of the total tropical peatland carbon pool.

Table 1. Best estimate area and carbon pool of tropical peatlands on a regional basis (derived from Page *et al*., 2011a)

Region	Best estimate of area (km^2)	Best estimate of carbon store (Gt)
Africa	55860	6.93
Southeast Asia	247778	68.52
South America	107486	9.67
Other	29901	7.07
TOTAL	441025	88.60

Table 2. Regional estimates of tropical peatland areas and carbon stores as proportions of the total tropical and global peatland areas and carbon stores. Based on tropical peatland area and carbon store (Table 1) and best estimates of the global peatland area of 3,997,435 km^2 (Page *et al*., 2011a) and the global peatland carbon pool of 478 – 610 Gt (derived from Immirzi *et al*. (1992), Gorham (1991) and Page *et al*. (2011a)).

Region	Best estimate of area (km^2)	Best estimate of carbon store (Gt)
Africa	55860	6.93
Southeast Asia	247778	68.52
South America	107486	9.67
Other	29901	7.07
TOTAL	441025	88.60

In Southeast Asia, 31,000 km^2 of peatland had been converted to industrial plantation by 2010 (Miettinen *et al*., 2012), equal to 20% of the peatland in that region (Malaysia and Indonesia, excluding the Indonesian provinces of Papua and West Papua). A further 72,000 km^2 of peatland had been subject to a range of other anthropogenic disturbances involving either regulated or unregulated drainage (e.g. small-holder agriculture, fire etc). Together this amounts to about 42% of the peatland area. However, even for this region's remaining forested peatlands, there are few, if any, areas now remaining outside of the Indonesian provinces of Papua and West Papua that have not been affected in some way by logging and/or drainage.

In South America, the extensive peatlands of the Amazonian headwaters in Peru (c. 50,000 km^2, ~50% of South America's tropical peatland area) remain in an essentially intact condition (Lähteenoja and Page, 2011), although there is an increasing threat of damage from gold-mining in some locations (e.g. 40% of the Madre de Dios River wetlands in southern Peru are impacted by gold-mining (Householder *et al*., 2012)). There is a potential for future damage as a result of exploration for and exploitation of oil reserves in the Amazon basin (Lähteenoja and Page, 2011) and hydrological changes as a result of upland deforestation. In Brazil, there are estimated to be ~25,000 km^2 of peatland, with Joosten (2010) noting that ~3000 km^2 are impacted by anthropogenic activities, although Lähteenoja (pers. obs.) found no evidence of widespread disturbance. For South American tropical peatlands as a whole, we assume that only ~5% (~5300 km^2) have been subject to some form of anthropogenic activity.

In Africa, Joosten (2010) reports for the year 2008 an area of ~12,500 km^2 of degraded peatland for those countries with a tropical peatland resource listed by Page *et al*. (2011a). This is equivalent to ~22% of the total tropical peatland area on this continent. Many African peatlands are still in an intact condition (e.g. those of the Congo basin, Greta Dargie pers. comm.) while others are subject to a range of degradation pressures, e.g. smallholder agriculture and extraction for peat briquette manufacture.

Table 3. Best estimate of areas and proportions of tropical peatlands impacted by anthropogenic activities by region (see text for details; N.B. value for Southeast Asian peatland is based on deforested area, with many remaining forests impacted by logging and/or drainage).

Region	Best estimate of area (km^2)	Best estimate of carbon store (Gt)
Africa	55860	6.93
Southeast Asia	247778	68.52
South America	107486	9.67
Other	29901	7.07
TOTAL	441025	88.60

DISCUSSION AND CONCLUSIONS

Tropical peatlands, with a best estimate area of 441,025 km^2, comprise 10 to 16% of the global peatland extent (Page *et al.*, 2011a). Southeast Asian peatlands alone represent between 6 to 8% of the global peatland resource by area, with a revised best estimate for the global peatland carbon store of 480 to 610 Gt. On this basis, the tropical peat carbon pool is 14-19% of the global peat carbon store (Page *et al.*, 2011a).

Peatlands across the tropical zone are subject to various forms of anthropogenic impacts, especially in Southeast Asia where the majority of the resource is located but where the rate of conversion to industrial-scale plantation agriculture has been the most rapid (Miettinen and Liew, 2010; Miettinen *et al*., 2011, 2012). Applying an emission value of 86 Mg CO_{2-eq} ha^{-1} yr^{-1} (averaged over a 50 year period after drainage) for CO_2 emissions arising from tropical peatland subject to intense and regulated drainage (typical of industrial plantations on deep peat with an average water table depth of around 0.75 m) (reviewed by Page *et al*., 2011b, citing Hooijer *et al*., in press; Jauhiainen *et al*. 2012) provides a peat-derived carbon emission of 230 Mt CO_{2-eq} (Miettinen *et al*., in press), representing an estimated annual loss of 0.1% of the regional peat carbon store. This emission value only pertains, however, to peatlands converted to industrial scale plantations and excludes the emissions arising from other areas of deforested and drained peatland. It also excludes emissions from deforestation and fire, which can in themselves be considerable (e.g. Page *et al*., 2002). Thus total annual peat-derived emissions are likely to be at least two or three times this estimate.

Given that African peatlands have a much smaller unit area than those of Southeast Asia and are also not subject to the same level of industrial-scale exploitation, associated carbon emissions are presumed to be occurring at a much lower rate. Some African countries still have extensive areas of peatland in an intact condition which are expected to continue as a net carbon sink. The least impacted tropical peatlands are those in South America. These will likely maintain their carbon sink function, at least over the short to medium-term, since they are in remote locations where levels of human impact are low, although there are increasing threats of disturbance from resource exploitation.

Improved knowledge of the peatland resource in tropical regions is vital in order to provide greater certainty on the magnitude of the tropical peatland carbon pool and to better understand the likely scale of greenhouse gases to the atmosphere resulting from changes in tropical peatland use. For the Southeast Asian region, projections of future industrial plantation conversion rates, based on recent historical rates, indicate that 60,000 to 90,000 km^2 of peatland may be converted to plantations by the year 2020, unless land use planning policies or markets for products change. This will increase the annual carbon emissions from peat oxidation alone to over 450 Mt CO_{2e} (Miettinen *et al*., 2012 & in press), i.e. an annual loss of 0.2% of the peat carbon pool. While the threats to the Southeast Asian peatland resource and its continued existence as a carbon store are relatively well documented, the extent of and anthropogenic impacts on the peatlands of South America and Africa continue to be largely uninvestigated and therefore their role in regional carbon cycling remains poorly understood.

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