TROPICAL PEATLANDS: DISTRIBUTION, EXTENT AND CARBON STORAGE – UNCERTAINTIES AND KNOWLEDGE GAPS

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SUMMARY

Although tropical peatlands are said to be globally significant carbon sinks that store large amounts of carbon, the data on which this information is based are subject to uncertainty and error. It is estimated that over half of the tropical peatland area is located in Southeast Asia, but there are no up-to-date and accurate measures of the precise location and extent of this resource, especially because of rapid land-use change developments in recent years. When areal extent and thickness data are combined to derive estimates of carbon content and compute the magnitude of tropical peatland carbon pools, uncertainties are compounded. This paper reviews the current state of knowledge and degree of uncertainty on the extent of tropical peatlands globally and their carbon stocks. Recent interest in the carbon storage potential of tropical peatlands, the magnitude of emissions from them and their importance in climate change processes should lead to more detailed field and remote sensing surveys and accurate data inventories in order to improve the state of knowledge.

Keywords: Tropical peatland; inventory; carbon sink; carbon store; climate change

INTRODUCTION

In his report on the peat resources of developing countries published in 1985, Charles Shier commented “In contrast with the peat deposits of the Northern temperate and boreal zones, which have been comparatively well surveyed, classified and quantified, tropical peat resources are as yet poorly investigated and documented” (Shier 1985). In the 20-year period since that report was published, the level of investigation and documentation of this important resource has not made significant progress. Published reviews repeat earlier data sources and little additional, verified information is added.

We believe that an improved understanding of the magnitude of the tropical peatland carbon store is now essential given the current interest in:

(1) Emissions of greenhouse gases (GHGs) from drained and degrading tropical peatlands (Hooijer *et al.* 2006; Page *et al.* 2002). A failure to account for these emissions could lead to underestimates of future rates of increase in atmospheric GHGs and the extent of anthropogenic climate change.

(2) The role that tropical peatlands could play in carbon offset and carbon trading agreements.

In presenting this paper we admit that we do not bring anything in the way of new data. Rather we highlight the situation and, most importantly, identify important data gaps and data uncertainties. As a result, we stress the importance of identifying data sources and specifying uncertainty and range or error in publishing or publicising information on tropical peatland, especially when it is concerned with carbon sinks, stores and losses.

Contested Definitions – What is peat? And what is tropical peat?
The definition of peat is variable although all authors agree that it is a layer of partially decomposed vegetation with a high proportion of organic matter. As examples, (a) Andriesse (1988) defines peat as organic soil that contain more than 50% organic matter in the upper 80 cm; (b) in the glossary of Rieley and Page (2005), the percentage of organic matter is required to be 65%, but thickness is reduced to 50 cm; and (c) Joosten and Clarke (2002) specify a minimum thickness of 30 cm of material containing at least 30% organic material.

A review of the literature also provides a variety of definitions of the term tropical peat, based on how authors define *tropical*. Throughout this paper, we refer to tropical as being between the Tropics of Cancer and Capricorn, incorporating both lowland and upland peat, although, owing to altitudinal effects on climate, the latter may have formed under temperate, rather than tropical, conditions. Some other authors, however, use different definitions, for example, peat that results from surplus rainfall and high temperatures (Andriesse 1988), thus including some areas in the sub-tropics (e.g., the Florida Everglades).

DATA SOURCES
Numerous data sources have been used in this review, although they do not all contribute original data. The principal original sources of data are given in Table 1. Many of these data sources quote a range of values and some subsequent authors reference only the median value or the upper or lower limit without citing the range and its associated uncertainties (e.g., Joosten and Clarke (2002) give only the upper value of 270,000 km^2 for the area of Indonesian peatland). As an example of the complex nature of the data trail, Figure 1 shows the values for the area of tropical peatland in Indonesia.

Table 1 Main data sources showing those targeting tropical peatlands and those with a more global view

Global inventories or inventories for developing countries	Tropical Inventories
Bord na Mona (1984)	Shier (1985)
Immirzi *et al.* (1992)	Andriesse (1988)
Joosten (2004)	Rieley *et al.* (1996)
Joosten and Clarke (2002)	Rieley and Page (2005)
Kivinen and Pakarinen (1981)	
Lappalainen (1996)	

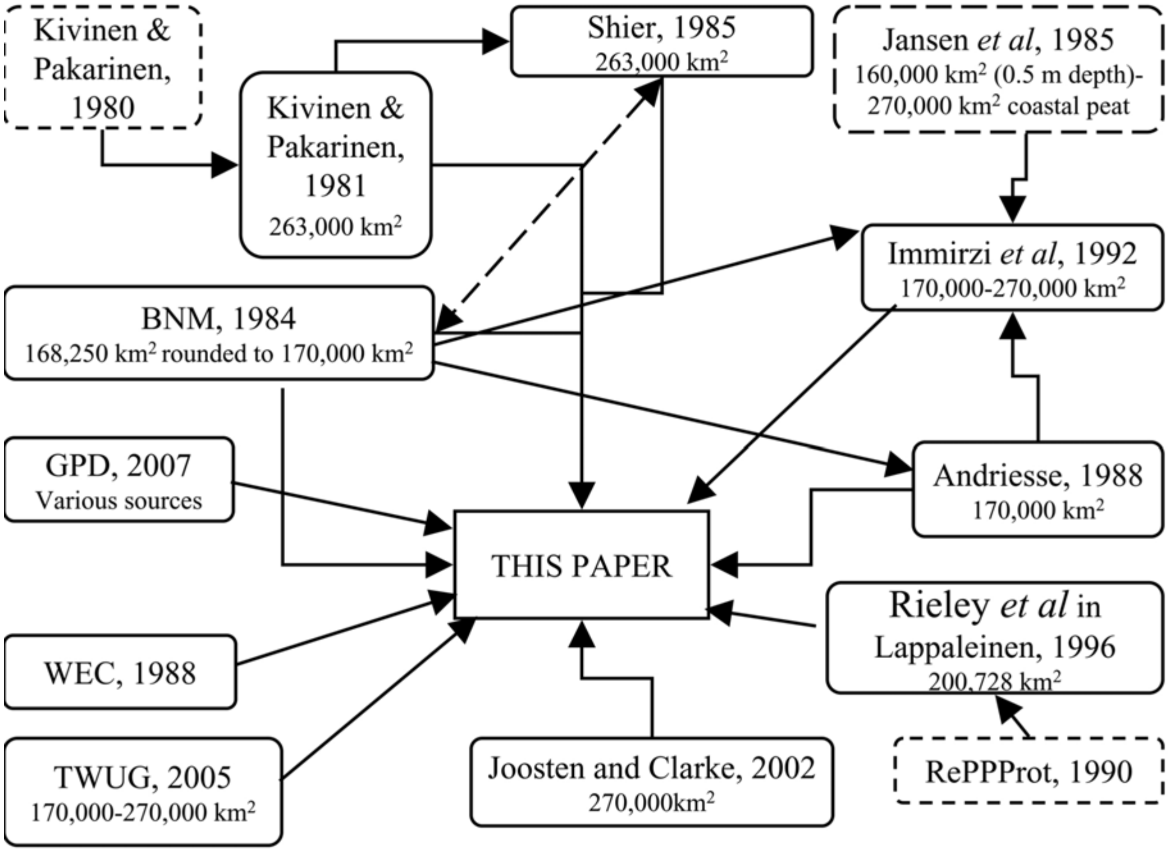

Figure 1 Data sources on the area of tropical peatland in Indonesia, BNM is Bord na Mona (1984), GPD is Joosten (2004), WEC is from www.worldenergy.org/wec-geis/publications/reports/ser/peat/peat.asp and TWUG is Rieley and Page (2005). Dashed lines around a reference indicate that a copy of the reference is being sought.

DATA EVALUATION

Area

For the purposes of illustrating the range of published values for the total tropical peatland resource, the ranges of area values from the various source materials were tabulated and the minimum and maximum values noted for each country. Table 2 gives these statistics by region and, for Southeast Asia, by country. Using Indonesia as an example, the highest estimate (270,000 km^2) is provided by Jansen *et al.* (1985) and cited by a number of other authors (Figure 1), whilst the lowest value of 168,250 km^2 is given by Bord na Mona (1984). The latter value is also rounded and used in a number of the other inventories (e.g., Rieley and Page, 2005; Immirzi *et al.*, 1992). Our purpose is not to criticise these differences but rather to point out the range of values and to emphasise that in future publications these ranges should be acknowledged. It should also be noted that most of these values are derived from pre-1990 sources. There has subsequently been considerable land development in most of these regions and countries and, since deforestation and drainage can lead to rapid oxidative losses of organic material, there has likely been a reduction in the area of peatland which is not accounted for in these estimates. An additional problem is that natural peatland converted to another land use may then not be classified as a peatland but as agriculture even though considerable amounts of peat may remain.

Table 2 Maximum and minimum values for area of tropical peatland (km^2) from sources in Table 1.

Region	Area (km2) Minimum	Maximum
Africa	26607	88657
Asia (Mainland)	622	6245
Central America	14465	25935
Pacific	190	21240
South America	37136	96380
Brunei	100	1000
Indonesia	168250	270000
Malaysia	22500	27300
Papua New Guinea	5000	28942
Philippines	60	2400
Thailand	394	680
Vietnam	100	1830
Asia (Southeast) Total	196404	332152
Total	275424	570609

Thickness, Volume and Carbon Store

Data on peat thickness are much more limited than data on area because the only reliable source of information is derived from time-consuming direct measurement in the field. For some countries a range of peat thickness values is provided, for example in Indonesia (RePPProT, 1990). For many other countries, available thickness data are limited and estimates of peat volume must accordingly account for such data gaps. As part of a more detailed report on these issues we will present values for peat thickness obtained from a variety of peat databases and publications describing individual sites used in palaeoecological studies (this report will be available shortly on the Carbopeat project website, www.carbopeat.org). In the absence of accurate data on the thickness of tropical peats, authors presenting regional or global estimates for tropical peat volume have applied mean thickness values. Immirzi *et al.* (1992), for example, applied a thickness value of 1.5 m for all tropical peatlands, although they fully recognised the problems associated with applying one thickness value to all countries. In a Southeast Asian regional study, Hooijer *et al.* (2006) attempted a more precise estimation by applying (a) a range of peat thickness values for Indonesian peatlands based on data from Wetlands International (2003, 2004), which assumes 42% of peatlands exceed a thickness of 2 m; (b) an average thickness value of 3 m for peatlands in Malaysia and Brunei, and (c) a value of 1.5 m for peats in Papua New Guinea.

For the purposes of this study we illustrate the range of peat volume values obtained by applying average depth values of 1.00 and 2.00 m to the global area estimates (Table 3). A depth of at least 2.00 m is certainly applicable to Indonesian peatlands where systematic drillings in several large peat-covered catchments have indicated that this is a conservative estimate. We have calculated a minimum peat volume by using the 1.00 m depth for the minimum area and a maximum volume by using the maximum area and a depth of 2.00 m. In turn, these volumes were used to calculate the amount of carbon stored using appropriate carbon densities. In one case study of peatlands in Central Kalimantan, Indonesia, Shimada and Takahashi (1999) give a range of values of carbon density for different types (location) of peat between 49 and 88 kgm^{-3}. In the calculations for Table 2 we have used a value for carbon density of 60 kgm^{-3}. As noted, for example, in Immirzi *et al.* (1992), the amount of carbon stored in a tropical peat profile will vary with both depth and location.

Table 3 Estimates of the amount of carbon stored in tropical peatlands based on (i) the minimum area value (Table 2) and a peat thickness of 1 m and (ii) the maximum area value and a thickness of 2 m. (In each case 60 kgm^{-3} is used for the volumetric density of carbon).

	Mass carbon (Gtonnes)	
Region	**Lower**	**Upper**
Africa	1.596	10.639
Asia (Mainland)	0.037	0.749
Central America	0.868	3.112
Pacific	0.011	2.549
South America	2.228	11.566
Brunei	0.006	0.120
Indonesia	10.095	32.400
Malaysia	1.350	3.276
Papua New Guinea	0.300	3.473
Philippines	0.004	0.288
Thailand	0.024	0.082
Vietnam	0.006	0.220
Asia (Southeast) Total	11.784	39.858
Total	16.525	68.473

From Table 3, we provide a range of estimates for the total tropical peatland carbon pool of 16.5-68.5 Gt[1]. For comparison, Hooijer *et al.* (2006) report the amount of carbon stored in lowland peatlands in selected countries in SE Asia as 42 Gt. In another recent study, Jaenicke *et al.* (Pers. Comm.) suggest that Indonesian peatlands alone may store more than 52 Gt carbon. Using the latter value would increase the Southeast Asian regional carbon pool to about 60 Gt.

DISCUSSION AND CONCLUSIONS

Data Uncertainties

This paper has highlighted the following data uncertainties and knowledge gaps:

(a) The lack of up-to-date areas for most of the global tropical peatland resource.
(b) The ranges of variation that exist in estimates of area, which are not always acknowledged by authors citing original data sources, and which can lead to bias in the subsequent results.
(c) The almost total absence of accurate thickness data, although recent work by Wetlands International (2003, 2004) has attempted to address this deficiency with regard to some Indonesian peatlands.
(d) A wide variation in the values ascribed to the tropical peatland carbon pool and hence its likely role in the global carbon cycle.

Most tropical peatlands, especially in Southeast Asia, are now undergoing rapid land-cover and land-use change. Therefore, in addition to providing accurate estimates of the current tropical peatland carbon store, we also need to have a better understanding of current land-use practices (including fire) on tropical peatlands as this will enable improved estimates of greenhouse gas emissions and role in global climate change.

It may be possible to address some of these uncertainties using recent advances in earth observation technologies. Several studies have shown that it is possible to identify natural lowland peat swamp forest using remote sensed imagery and that this forest can be discriminated from other types of lowland rainforest vegetation on the basis of its

[1] Gt = gigatonne = t x 10^9

spectral characteristics. Once peat swamp forest has been converted to some other land cover (e.g. agricultural crop, plantation forest, or secondary, non-forest vegetation), however, earth observation techniques can no longer be used because these land-cover types appear similar regardless of whether they are on peat or mineral soils. Advances in Lidar technologies and airborne high-resolution photogrammetry may permit identification of unique peatland topography (i.e., peat domes). However, these methodologies do not address the question of peat thickness, which still requires time consuming field investigation.

There is an urgent need to develop agreed standards for an inventory of tropical peatland, especially area and volume, and standardized procedures for determining peat stores and carbon stocks. Standard approaches are required so that we can (a) measure and predict the impacts of climate change; fire and land-use change on these stocks now and in the future and (b) provide a reliable benchmark for financial mechanisms to protect carbon stores.

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