Chapter 2
Tropical and Subtropical Peats: An Overview

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2.1 Introduction

Peats are frequent in cool temperate and boreal regions, but occur also in tropical and subtropical areas. While the distribution and characteristics of peats at higher latitudes have been well documented, peats at lower latitudes are less known. Unrecorded tropical peat reclamation efforts date back several centuries, as, for instance, the reclamation of coastal soils undertaken by the Dutch in the seventeenth century north of Colombo in Sri Lanka. However, it was not until the late 1890s when Koorders provided the first formal description of tropical peats from the forests of Sumatra (Andriesse 1988). Since this early reference, knowledge on tropical peatlands has made progress but by far not at the same pace as the knowledge on temperate and boreal peatlands. The lack of systematic surveys limits the scope of the updating reviews (Shier 1985). One of the most comprehensive documents on tropical and subtropical peats is from the late 1980s (Andriesse 1988).

This chapter provides an overview of tropical and subtropical peats. After describing worldwide peat extent and distribution, the factors controlling peat formation and development, peat features and peat classification are analyzed. The chapter also addresses issues related with peats and peatlands as resources.

2.2 Peat Extent and Distribution

Our knowledge about the areal extent of nontropical peats is supported by reliable statistics, mainly because of the early importance of peat as a source of energy. For tropical peats, by contrast, it was not until the mid-1900s that their extent became better known (Polak 1950). Statistics are not always directly comparable because they may reflect different acceptations and definitions of peat and peatland. The concept of peat varies from that of true peat that contains 100% organic material to that of organic soil defined on the basis of a combination between percent organic

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matter (organic matter = organic carbon × 1.724) and thickness of the organic horizons. According to Andriesse (1988), organic soils have more than 50% organic matter in the upper 80 cm. For Rieley and Page (2005), organic soils are at least 50 cm thick and contain at least 65% organic matter, while Joosten and Clarke (2002) fix these thresholds at 30 cm thickness and 30% organic material. In Histosols, as defined in the USDA Soil Taxonomy (USDA 1999), the amount of organic matter is at least 20–30% in more than half of the upper 80 cm of the soil. Similarly, the term peatland is frequently used as a generic proxy of concepts which are not strictly synonymous, such as wetland, peatswamp, moor, muskeg, pocosin, bog, marsh, mire, and fen (Andriesse 1988; Joosten and Clarke 2002). Martini et al. (2006b) recognize four basic classes of peatland in nontropical environments: bogs, fens, swamps, and marshes, the first one being ombrotrophic and the others being minerotrophic with additional distinctive attributes based on acidity, type of vegetation cover, and water regime. All types of peatland are wetlands, but not all wetlands are peatlands. The global wetland area is estimated at 5.3–6.4 M km^2 (Matthews and Fung 1987; Lappalainen 1996), while only about 60–75% of this surface is actually covered by peat (Armentano and Menges 1986; Andriesse 1988; Wikipedia 2008).

2.2.1 Peats in Temperate and Boreal Regions

Worldwide, peatlands cover an estimated 4.26 M km^2 (Bord na Mona 1984; Andriesse 1988; Chimner and Ewel 2005; Chimner and Karberg 2008). This represents about 3% of the global land mass. The largest proportions concentrate in the temperate and boreal regions of North America (49%) and Eurasia (42%) (Table 2.1). Russia has the world's largest contiguous peat bog, while Canada has the largest total area of peatland, estimated at 1.7 M km^2 (Wheeler 2003).

A recent update of the areas covered by peat and peat-topped soils in Europe, derived from the 1:1,000,000 European Soil Database covering roughly the EU territory, provides a surface area of 291,600 km^2 (Montanarella et al. 2006).

Table 2.1 Worldwide distribution of peatlands

Continent	km^2	%
North America	2,096,400	49.19
Eastern Europe	1,519,578	35.65
Western Europe	259,862	6.10
Asia	248,865	5.84
South America	61,730	1.45
Africa	48,565	1.14
Central America	25,240	0.59
The Pacific	1,650	0.04
Global peatlands	4,261,890	100.00

Source: Data summarized from Bord na Mona (1984) and Andriesse (1988)

This extent is not substantially higher than the total peat area of 279,440 km^2 estimated by Bord na Mona (1984) for Western and Eastern Europe together (ex-Soviet Union excluded). In fact, these two figures are not directly comparable because of, among other reasons, recent changes in the territorial configuration of Europe and the inclusion of peat-topped soils (0–30 cm) in the concept of peatland. In spite of that, the updated figure reflects progress made and accuracy achieved in peat mapping using modern information technology. In some cases, peatlands may cover more than 10% of the surface area of individual countries, such as in Finland (30%), Estonia (22%), Ireland (17%), Netherlands (16%), Sweden (16%), Latvia (12%), and United Kingdom (11%). Finland alone concentrates almost one-third of the peat and peat-topped soils in Europe, and Sweden more than a quarter (Montanarella et al. 2006).

2.2.2 Peats in Tropical and Subtropical Regions

From a practical point of view, based on peatland similarities for reclamation and management purposes, Andriesse (1988) sets the boundaries between tropical–subtropical peats and temperate–boreal peats at latitudes 35° North and South. This territorial belt includes Southeast Asia, most of Africa, and a large stretch of the Americas from Florida and North Carolina to southern Brazil and Uruguay.

The most relevant features that distinguish intertropical lowland peats from temperate–boreal ones are surplus rainfall and high temperatures (Andriesse 1988). High temperature, with little diurnal and seasonal variations, accelerates the rate of peat oxidation. Rainfall controls peat hydrology and also has an effect on vegetation type and composition. Peat initiation is mainly a response to substrate waterlogging because of abundant rainfall or flooding by river overflow in areas with impeded drainage. Many tropical peatlands in low-elevation areas are forest-covered peat swamps, and that represents a striking difference with temperate peatlands commonly covered by sedges and moss. In the subtropical areas of the mid-latitudes, surplus rainfall remains important, but the annual temperature regime is more contrasted. Peatlands and peats occurring on highlands within the tropical and subtropical belts, such as, for instance, in Central Africa above 2,000 m elevation, are closer to those of the temperate regions. Worldwide, peat development has taken place over thousands of years converging at the end into the formation of ombrotrophic peat bogs in both temperate and tropical regions.

Compared with the areal importance of peat in temperate and especially in boreal regions, peatlands are much less extensive in tropical and subtropical environments. Only 0.36 M km^2 peatland, or 8.5% of the global 4.26 M km^2, occur in the warm and moist regions of the world, especially in Southeast Asia in the areas surrounding the South China Sea and areas in Papua-New Guinea that together concentrate 68% of the known tropical peats (Immirzi et al. 1992). Other areas with peatlands of some extent are the Caribbean and the basins bordering the Gulf of Mexico, the Amazon basin, and the wet equatorial belt of Africa, especially

Table 2.2 Extent of tropical and subtropical peatlands

Region	km^2	Global %	Tropical %
Southeast Asia	202,600	4.65	56.6
Caribbean	56,700	1.30	15.8
Africa	48,600	1.11	13.6
Amazonia	15,000	0.34	4.2
South China	14,000	0.32	3.9
Other regions	21,100	0.49	5.9
Tropical and subtropical peatlands	358,000	8.21	100.0

Source: Andriesse (1988)

Table 2.3 Areal ranges of tropical peatlands

Region	Minimum km^2	Maximum km^2
Southeast Asia	196,404	332,152
South America	37,136	96,380
Africa	26,607	88,657
Central America	14,465	25,935
Asia (Mainland)	622	6,245
Pacific	190	21,240
Total areas	275,424	570,609

Source: Page et al. (2007)

the depressional areas around the Gulf of Guinea (Table 2.2). Data on peats and peatlands in the tropics and subtropics are much less accurate than those concerning the higher latitudes, mainly because they are derived from small-scale soil maps in which organic soils are frequently mapped in association with poorly drained mineral soils. Andriesse (1988) considers that the extent of organic soils in the Amazon basin and in the wet equatorial belt of Africa is underestimated and that peat deposits in the tropics and subtropics might occupy areas larger than those so far reported.

As soil and land inventories proceed, data on peat extent are becoming more accurate. However, there are still large data gaps and data discrepancies between sources. According to Page et al. (2006), the total area of undeveloped tropical peatland is in the range of 310,000–460,000 km^2, which is about 10–12% of the global peatland extent. Page et al. (2007) computed data from different sources and found that the range between low and high estimates can be considerable (Table 2.3). In the case of Indonesia, for instance, estimates range from 168,000 km^2 (Bord na Mona 1984) to 270,000 km^2 (Jansen et al. 1985) for the same reference period. For the tropics as a whole, peatland area estimates vary roughly from simple to double, between a minimum of 275,424 km^2 and a maximum of 570,609 km^2 (Page et al. 2007) (Table 2.3). Other estimates set the tropical peat surface area closer to 0.5 M km^2 (Immirzi et al. 1992; Lappalainen 1996; Maltby and Proctor 1996). While the knowledge about tropical lowland peats is steadily increasing, tropical highland peats still remain poorly documented. For instance, all papers on tropical peatlands presented at the most recent (2007) international peat congress held in Tullamore, Ireland, deal exclusively with lowland peats (Farrell and Feehan 2008).

In Central and South America as a whole, peatlands cover about 87,000 km^2, representing 2% of the worldwide peat distribution (Table 2.1). The largest part of this extent is in the Caribbean (56,700 km^2) and in Amazonia (15,000 km^2) that together account for 20% of the tropical peatland areas (Table 2.2). A recent estimate (2007) sets the extent of tropical peatlands in South America between a minimum of 37,000 km^2 and a maximum of 96,000 km^2 (Table 2.3). Peats in tropical and subtropical South America are found in a variety of landscapes, including coastal plains (e.g., deltas of the Amazon and Orinoco rivers), inland sedimentary basins (e.g., Llanos in Colombia and Venezuela, Pantanal in Brazil), and highlands (e.g., filled glacial lakes in the Andes, (pseudo-)karstic depressions and other kinds of pond on the Guayana sandstone plateaus and mesetas).

2.3 Peat Formation and Development

Peat formation results from an unbalance between accumulation and decomposition of organic materials. In places where the speed of deposition exceeds the rate of decay, there will be a surplus of organic matter. Deficit of decomposition is caused by insufficient or low biological activity as a consequence of adverse environmental factors, basically excessive acidity and/or prolonged waterlogging causing anaerobic conditions. In tropical lowlands, the fluctuation of the groundwater level, controlled by rainfall and evapotranspiration, has an important effect on peat formation, especially in forest swamps (Ludang et al. 2007). In tropical highlands, lower temperatures slow down the rate of biomass decomposition in contrast to what occurs in the warm-to-hot lowland areas.

2.3.1 Topography and Water Regime

Topography plays an important role in water concentration and in situ retention. Concave, basin-shaped sites favor water accumulation, especially when coupled with rock or soil substrata of low permeability. Such relief types occur in a variety of landscapes, including coastal tidal marshes, inland depressional plains, undulating peneplains, karstic plateaus, volcanic reliefs, and glacial and periglacial mountains, all present in the tropics and subtropics. In temperate and boreal regions, glacial till plains offer the best conditions for peat formation.

Waterlogging is the main factor controlling peat initiation because it allows the colonization by adapted pioneer vegetation and the preservation of at least part of the decay residues. Water concentrates and stagnates in depressional sites where water outflow is less than water inflow so that excess water remains in situ. Water inflow is runoff, ground- and rainfall water, while water outflow includes water

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