

Tropical Forests of Xishuangbanna, China¹

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ABSTRACT

Lowland tropical forests once covered a large fraction of tropical southern China, but currently have an extent of *ca* 633,800 ha, mostly in Xishuangbanna of southern Yunnan. The Xishuangbanna region has a typical monsoon climate with a mean annual temperature ranging between 15.1°C and 21.7°C, and precipitation between 1200 and 2500 mm. There is a pronounced dry season between November and April with frequent occurrence of heavy fog. Rainfall during the wet season between May and October accounts for over 80 percent of total annual precipitation. Water deposition from fog accounts for over one-third of total water input during the dry season in the forests, suggesting an important role that fog may play in pushing up the northern limit of tropical rain forest in Southeast Asia.

Key words: climate; geography; soil; tropical rain forest; Yunnan.

ASIA ONCE SUPPORTED ABOUT ONE-FOURTH OF THE WORLD'S TROPICAL RAIN FORESTS, and currently accounts for approximately 20 percent of their global distribution (Food and Agricultural Organization of the United Nations 2001). Asian rain forests cover a wide geographic range and are globally important for their high biodiversity and productivity (Myers *et al.* 2000, Houghton 2002). Nevertheless, the ecology and dynamics of Asian rain forests are less well documented than those of the Neotropics. The forests of Southeast Asia (*e.g.*, Malaysia, Indonesia, and Thailand) have received the most attention, mainly focusing on the Dipterocarp forests occurring immediately westward of Wallace's Line (Van Oosterzee 1997). Asian rain forests, however, extend northward to the lower valleys of the southern Himalayan foothills, where the region receives warm and moist air masses from the southwestern monsoon. Little information on the ecology of these northernmost rain forests of tropical Asia has been published in English.

Tropical climatic conditions occur over a small proportion of China's landmass. Species-rich tropical forests covered much of China's southern border, from southeastern Xizang (Tibet) to southern Yunnan, extending to southwestern Guangxi, including southern Taiwan and Hainan Island (Fig. 1). Forest cover was 42.5 percent in tropical China in 2000 with a total area of 11.257 million ha, of which about 5.44 million ha are secondary forests (Hou 2003). There are only about 633,800 ha of old growth high diversity lowland tropical rain forests in China today, and much of these old growth lowland tropical forests are located in Xishuangbanna of southern Yunnan Province.

Very little information about the forests of Xishuangbanna was available prior to the 1950s due to limited access to this remote region. The existence of true lowland tropical rain forest in Xishuangbanna was somewhat debated by botanists, because of its northern

latitude (21–22°N) and seasonal climate. The first botanist who described the tropical forests in southwestern Yunnan was Wang (1939). Few efforts had been made to study the Xishuangbanna forests since then, until a joint Chinese–Russian expedition during the late 1950s and early 1960s led to publications in Russian and Chinese on the flora and fauna of Xishuangbanna (see Zhu *et al.* 2006).

The forests of Xishuangbanna harbor biodiversity that is important both globally and nationally. Xishuangbanna is included in the Indo-Burma biodiversity hotspots and contains over 5000 species of vascular plants, comprising 16 percent of China's total plant diversity (Li *et al.* 1996, Cao & Zhang 1997, Myers *et al.* 2000). The fauna of Xishuangbanna are no less diverse, as 36.2, 21.7, and 14.6 percent of China's birds, mammals, and reptiles, and amphibians occur in the region, respectively (Kou & Zhang 1987, Wang & Jin 1987, Yang *et al.* 1987). Despite Xishuangbanna's high biodiversity, general ecological information about the forests of the region has rarely been published for an international audience.

The objectives of this special section are to report basic ecological data for the Xishuangbanna region to enhance the understanding of tropical forests worldwide, and to stimulate future research about the ecology of these northernmost Asian tropical rain forests. Five papers describe the structure and function of tropical forests in Xishuangbanna. Zhu *et al.* (2006) provide an extensive review on the floristic composition and structure of forests in the region. Zheng *et al.* (2006a) estimate the biomass of a dominant tropical seasonal rain forest in Xishuangbanna. Tang *et al.* (2006) describe soil seedbanks in a dipterocarp forest that reaches up to 70 m in height, and Zhang *et al.* (2006) describe the phenology of fig trees in the area. Zheng *et al.* (2006b) examined the decomposition of plant litter. These studies suggest that tropical forests in Xishuangbanna are similar to rain forests in Southeast Asia in species composition and community dynamics, but differences in decomposition processes are more pronounced between Xishuangbanna and Southeast

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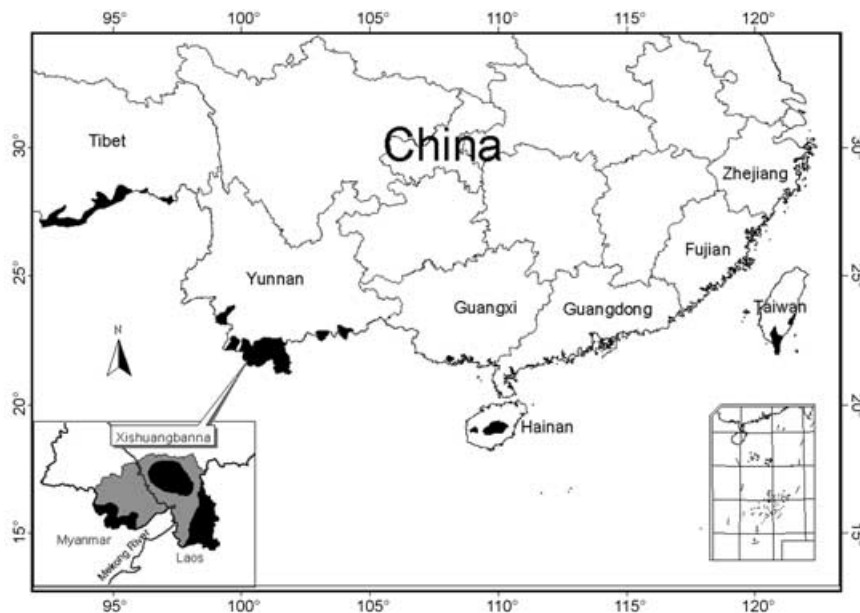


FIGURE 1. Distribution of the old growth tropical forests in China and the location of Xishuangbanna.

Asian tropical forests. Here, we provide a summary of the region's geography, climate, and soils.

GEOGRAPHY

Xishuangbanna lies between 21°08'N and 22°36'N, 99°56'E and 101°50'E (Fig. 1), situated in the southwestern Yunnan Province of China. The region has an area of 19,120 km². It borders Myanmar in the southwest and Laos in the southeast, and has mountainous topography, with mountain ridges running in a north–south direction, decreasing in elevation southward. Its elevation ranges from 491 m at the bottom of the lowest valley in the south (Mekong River) to 2429.5 m at the top of the mountains in the north. The uplift of the Himalayas leads to the penetration of warm and moist tropical air mass from the Indian Ocean to Xishuangbanna in the summer, and forms a barrier preventing cold air mass from the north reaching the region in the winter, allowing for the existence of tropical rain forest in its altitudinal and latitudinal northern limits. The Mekong River runs through the region from northwest to southeast. The western and northern parts of the region have high basins over a 1000 m elevation, with mountainous topography, whereas the south consists of hills with lower basins under a 1000 m elevation.

CLIMATE

The Xishuangbanna region has a typical monsoon climate. The annual solar radiation in the region is 116.724 Kcal/cm²/yr, and annual sunshine averages 1858.7 h. The annual mean temperature ranges from 21.7°C at an elevation of 550 m to 15.1°C at 1979 m, and the 20°C isotherm is equal to the 850-m elevation isoline.

The hottest month is June with a mean temperature of 17.9°C at 1979 m elevation, and 25.3°C at 550 m, while the coldest month is January with a mean temperature ranging from 8.8°C to 15.6°C (Liu *et al.* 2004). Temperature can exceed 38°C in March and April when relative humidity is below 40 percent. Annual precipitation increases from 1193 mm at Mengyang at 740 m elevation to 2491 mm at the summit of Nangongshan at 1979 m elevation.

The climate is strongly seasonal with two main air masses alternating during the year (Zhang 1986). Between May and October, the tropical Southwest Monsoon from the Indian Ocean delivers about 80 percent of the annual rainfall, whereas the dry and cold air of the southern edges of the subtropical jet streams dominates the climate between November and April. Annual precipitation is higher in the eastern part of the region than in the west. In the Xishuangbanna Tropical Botanical Garden (21°54'N, 101°46'E, 580 m asl), the long-term (1959–1998) annual mean temperature averaged 21.8°C (Fig. 2), with the annual cumulative temperature (the sum of daily temperature means >10°C) ranging between *ca* 7600°C and 7800°C. Annual precipitation averaged 1493 mm, of which 1256 mm (84%) occurred between May and October. Relative humidity averaged around 80 percent and frost was never recorded. Mean monthly precipitation greater than 200 mm occurred only in June, July, and August.

The dry season from November to April is further divided into cool–dry (from November to February) and hot–dry (from March to April) periods. The cool–dry period is characterized by the high frequency of heavy radiation fog during the night and in the morning on the lower hills and in the valleys. The hot–dry period is characterized by dry and hot weather during the afternoon and with heavy radiation fog during the morning only. The rainy season occurs between May and October, and is characterized by

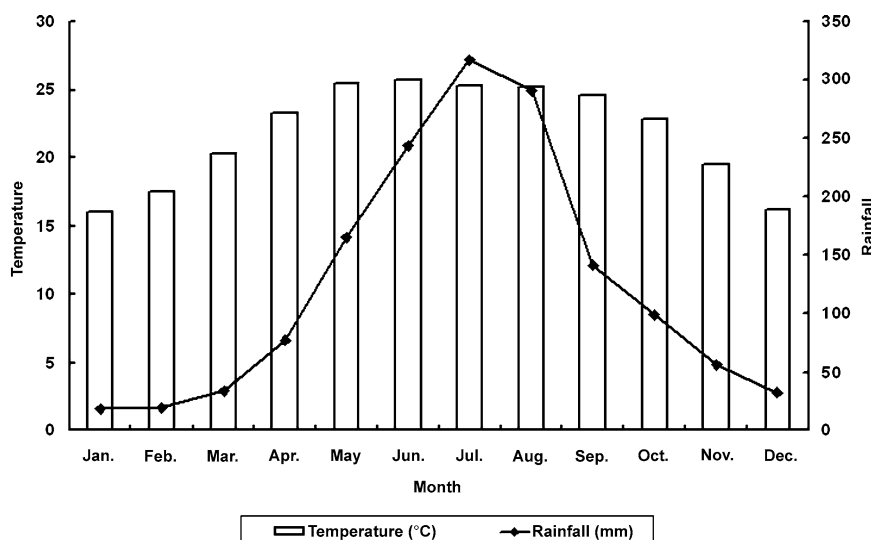


FIGURE 2. Mean monthly temperature and precipitation in Xishuangbanna tropical botanical garden between 1959 and 1998.

high rainfall from the southwest summer monsoon. Dense radiation fog occurs in the entire dry season, with an average of 146 foggy days per year in Mengla County in southern Xishuangbanna, 116 foggy days per year in Menglun in the center area of the region, and 126 foggy days per year in Mangao in the northwest. Water deposition from fog averaged 0.52 and 0.41 mm/d beneath the forest canopy, which account for 49 and 33 percent of total water input for the cool-dry and hot-dry periods, respectively (Liu *et al.* 2004). Fog presence and a high percentage of water deposition from fog can play an important role in easing plant water stress during the dry season.

SOIL

Soils in Xishuangbanna are derived from both igneous and sedimentary rocks. There are three main soil types in the Xishuangbanna region (Wang *et al.* 1996). A laterite soil developed from siliceous rocks, such as granite and gneiss, occurs between 600 and 1000 m elevation with a deep solum and thin humus horizon. A lateritic red soil, derived from sandstone substrates, occurs in areas above 1000 m elevation. Limestone hills have soil derived from a hard limestone substrate of Permian origin with a pH of 6.75. Other soil types are found in a limited area. The tropical rain forest and the montane evergreen-broad leaved forest of Xishuangbanna occur mainly on laterite and lateritic red soils with pH values of 4.5–5.5. Tropical seasonal moist forest occurs on the limestone-derived soils. Tropical monsoon forest is often associated with young soils along the riverbanks.

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