The background of the cover is a photograph of bamboo. Two thick, yellowish-brown bamboo stalks run vertically through the center. They are surrounded by lush green bamboo leaves and ferns, some of which are in sharp focus while others are blurred in the background.

Bamboo and Rattan in the World

Chief Editor: Jiang Zehui

China Forestry Publishing House



世界竹藤

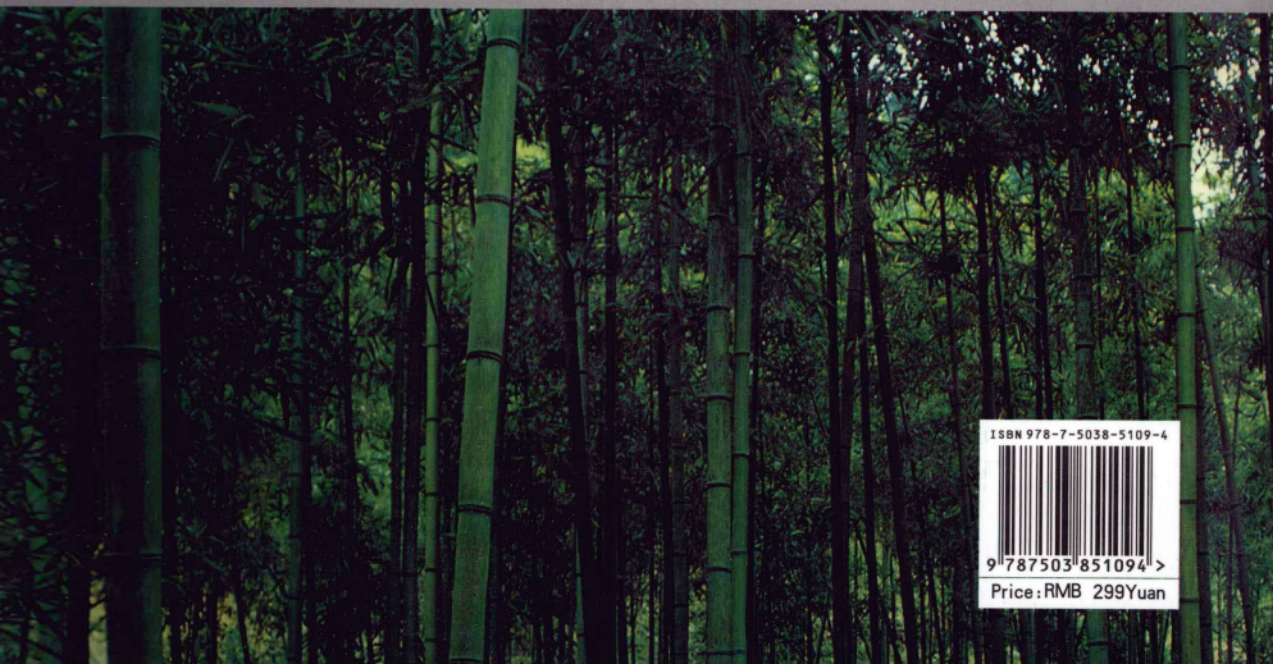
Bamboo and Rattan in the World

Widely distributed in Asia, Africa and Latin America, bamboo and rattan are the most important non-timber forest products among the world's plant and forest resources. These versatile plants have a great potential in poverty reduction, industry development and sustainable development in rural areas.

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Foreword

Jiang Zehui

Widely distributed in Asia, Africa and Latin America, bamboo and rattan are the most important non-timber forest products among the world's plant and forest resources. These versatile plants have a great potential in poverty reduction, industry development and sustainable development in rural areas.

As one of the countries that boast the largest number and widest distribution of bamboo species, China is richly experienced in research, production, processing and trade related to bamboo. In particular, the last decade sees a booming bamboo industry in rural China, which has contributed enormously to farmers' income generation, local economic development and environment improvement.

The International Network for Bamboo and Rattan (INBAR) is the only international organization devoted specifically to conservation and utilization of bamboo and rattan resources. The very fact that INBAR headquarters itself in China indicates the importance the Chinese Government attaches to bamboo and rattan development as well as China's leading role globally in bamboo and rattan research and development.

Relying on China's advanced experience, INBAR has undertaken many a publicity campaign, training programs and development projects of various kinds in its member countries since it was founded ten years ago. These efforts not only help them to explore their specific approaches to resource management and industry development, but also contribute to coordination between producing and consuming countries and sustainable development in the world.

In celebration of INBAR's 10th anniversary this November, we organize a team of leading experts in China on bamboo and rattan research to write this English edition of "Bamboo and Rattan in the World" by updating and supplementing the Chinese edition with the latest progress at home and abroad, in the hope of enhancing international experience sharing and cooperation.

This book introduces the achievements and development trends with regard to bamboo and rattan research in China and other countries. Both scientifically instructive and practically useful, the book covers a wide range of research and development fields and will be of great help as a guide in practice to sustainable development of bamboo and rattan in the world.

The chief editor of this book is Professor Zehui Jiang, and the deputy chief editors are Dr. Benhua Fei and Prof. Xuhe Chen. Prof. Zhenhua Peng and Yongde Yue are advisors and Dr. Jules Janssen from the Netherlands is the English editor. The first part on Bamboo was written by Zehui Jiang and Xing'e Liu (Chapter 1), Yulong Ding, (Chapter 2), Jianghua Xiao, Benzhi Zhou and Xuexin Shao (Chapter 3), Shaohui Fan and Zhimin Gao (Chapter 4), Maoyi Fu (Chapter 5 and 12), Haojie Wang and Jinhe Fu (Chapter 6), Yiping Lou (Chapter 7), Benhua Fei and Haiqing Ren (Chapter 8), Mingliang Jiang (Chapter 9), Xuhe Chen, Zheng Wang and Wenji Yu (Chapter 10), Guigan Fang (Chapter 11), Shenxue Jiang (Chapter 13), Yongde Yue (Chapter 14), Maxim Lobovikov, Zhimin Wu and Junqi Wu (Chapter 15), Zhenhua Peng and Xianchong Wan (Chapter 16). The writers for the second part on Rattan include Zehui Jiang and Guangtian Yin (Chapter 1), Guangtian Yin and Jinchang Yang (Chapter 2), Rongsheng Li and Zhaohui Wang (Chapter 3), Shineng Huang and Rongsheng Li (Chapter 4), Jinchang Yang, Yuzhang Wu and Wenhua Lu (Chapter 5), Shineng Huang (Chapter 6). All the Chinese text is reviewed by Prof. Zehui Jiang and the English text is polished by Dr. Jules Janssen.

On the occasion of INBAR's 10th anniversary, we would like to express our heartfelt thanks to all individuals and organizations including foreign experts who show interest in and render support to the publication of this book as well as to bamboo and rattan development.

Any comments from readers are very much appreciated.



Preface

Coosje Hoogendoorn

Bamboo and rattan are among the most important non timber forest commodities of the world. Together they represent a world trade of around 5 billion USD, and this is increasing every year. The booming global market for bamboo and rattan based products offers exiting opportunities both for rural development and for the mitigation of the threats to our environment. To realize this potential we need to make use of the state of the art knowledge about bamboo and rattan.

Although they are often mentioned together, bamboo and rattan are actually quite different commodities. Rattan is restricted to tropical forest environments in Asia and Africa. It is used mainly for weavings and furniture. Although it regrows faster than most trees in tropical forests, rattan still takes at least 8 years from seed to first possible harvest. Due to overharvesting and suboptimal policies for harvesting and transport of the raw materials, there is a shortage of good quality stems on the world market. Therefore the prices are high and illegal trade is significant.

Endemic bamboo species are found worldwide, on all continents except Europe and Antarctica. Bamboo has many and diverse uses, from sticks and baskets to food, textiles, surfboards and advanced construction materials. In addition bamboo is a very popular ornamental plant. Due to its fast growth bamboo is one of the most renewable sources of wood available. As far as trade is concerned, in most countries the primary product, the culms, are not very expensive, and a lot of value can be added along the production chain. Increasingly bamboo is valued for its contribution to environmental services. Its rhizomes are found to be excellent soil binders to prevent erosion. Also the large bamboos are very fast and very efficient CO₂ binders, an important factor for the development of measures to mitigate climate change.

The bamboo based industry is experiencing a real surge. From a minor role about 20 years ago, modern workshops and factories can now be found everywhere, and in particular in China. Many new products have been successfully developed, and are finding a market niche. This is due both to skillful adaptation of wood technologies to bamboo, enabling the commodity to enter the markets for construction and furniture, and it is due to the sustainable green image of bamboo, which is attracting more and more consumers worldwide to products which are high quality and environmental friendly. The examples from China show that this industrialization of the bamboo sector has benefited both investors and communities. This has resulted in a great interest from countries with high bamboo production potential, and a similar approach is now underway also in other parts of the world.

Bamboo's green image is offering a lot of potential market growth. However, many people argue that the increasing demand may pose serious threats to the sustainable cultivation and harvesting, to the green image of the resource, which is its most unique selling point. Fortunately, many leaders in the bamboo world regard this situation as a great opportunity for the sector to show that it can regulate and certify itself, providing the basis for further strong growth in a sustainable manner.

The International Network for Bamboo and Rattan was set up to help to realize the potential of bamboo and rattan for poverty reduction and environmental protection. It started as a secretariat supported by IDRC in South Asia and has evolved into a strong intergovernmental network with 34 member states. INBAR is now headquartered in Beijing, in China. It counts the governments of China, Canada and the Netherlands as well as IFAD among its many supporters. INBAR has activities all over the world. It has a focus on rural development and environmental protection through action research, and on the development of fair worldwide trading systems for bamboo and rattan, in particular through its activities as a CFC International Commodity Body.

This year INBAR is celebrating its 10th anniversary as an intergovernmental organization. This book reflects knowledge and major achievements in R & D and industrial applications of bamboo and rattan in China and in the world, and therefore it is also a celebration of the impacts that INBAR has had on fostering the science and technology of bamboo and rattan. It is not only a very valuable gift to the 10th anniversary of INBAR, but as it contains excellent reference material for practitioners and scientists alike, it is also an invaluable contribution to the future of bamboo and rattan as part of sustainable development and fair worldwide trading systems to reduce poverty and protect the environment.





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Bamboo

Chapter

1

Introduction

1. BAMBOO DISTRIBUTION

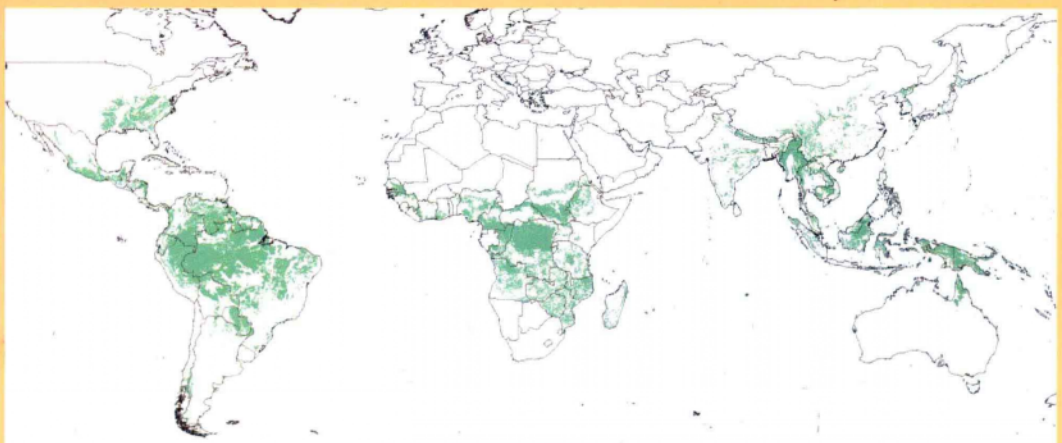
1.1 Distribution in the World

Bamboo is one of the most important forest resources. More than 1250 species, belonging to 75 genera, are being reported worldwide (Sharma, 1980; Scurlock, 2000), which are mainly distributed in the tropical and sub-tropical zone, and a few in the temperate and frigid zone. It usually grows with other tree species in mixed forest, and also occurs under the main storey. In the past, it did not receive much attention, but since the 20th century, it quickly began to appear as secondary bamboo forest in tropical and sub-tropical forests, due to its fast growth and strong propagation after the upper canopy species were cut. Because of its diverse usage and the high ecological and economic values, bamboo was planted at large scale and the artificial bamboo forest was developed. The secondary and artificial bamboo forest is expanding by the strong underground rhizomes. The total forest area on the land surface decreased year by year in recent years (according to the statistics, the cover rate of the world forest declined from 25% to 17%, the tropical forest cover disappears by 0.24 million km² every year and 0.46 km² every minute in the past 50 years) (Fangchun, 1999). On the contrary,

the area of bamboo forests increasingly expands, at a steady annual rate of 3% (Fangli et al. 2004). There are totally 0.22 million km² of bamboo forest all over the world and the annual production of bamboo is estimated to be 15-20 million tons. In the world, there are three regions, divided according to their geographical distribution: the Asian-Pacific, the American and the African region (Figure 1-1) (Wenyu, 1983 and Zehui, 2002). In the recent 20 years, bamboo was introduced to Europe, North America and Australia; thus new cultivating bamboo regions appeared different from the natural distribution regions.

1.1.1 Asian-Pacific region. This is the biggest bamboo region with very rich bamboo resources and large scale bamboo forests, located from 64°E in India in the West, up to 180°W in Oceania and Pacific Islands in the East, and from 42°S in New Zealand in the South up to 51°N in Japan in the North. There are about nearly 900 species in 40-50 genera, accounting for around 80% of species, volume and the area in the world (Fangchun 1992). Southeast Asia is the origin center of bamboo in the world, as well as one of the present distribution centers. The main countries producing bamboo

Global map of potential distribution of bamboo within existing forest cover




 Potential distribution of bamboo within existing forest cover

Figure 1-1 Global map of Distribution of bamboo

are: China, India, Japan, Myanmar, Thailand, Bengal, Cambodia, Vietnam, Laos, Malaysia, Indonesia, Philippines etc. In this region, 4/5 of the bamboo species is sympodial bamboos, and 1/5 are monopodial bamboos, in which there are over 100 species with a tall and straight culm form (an excellent property) and a fresh and edible shoot.

China and India have the most abundant bamboo resources and a better utilization of bamboo industry. According to the statistics, there are totally 48426 km² of bamboo forest in China, among which there are 33700 km² of Moso (*Phyllostachys pubescens*) bamboo forest, about 70 % of total pure bamboo forest (State Forestry Administration, P.R.China,2005). Sympodial bamboos, monopodial bamboos and compound mixed bamboos with a high cold resistance, adapted to tropical, subtropical zone and high elevation and latitude respectively, are all found in this area. Especially the central and south parts of Yunnan Province in our country have quite rich bamboo resources including a large amount of bamboo species with high economic value, in which the geographic element of flora is complicated. Taiwan province has 60 bamboo species, 1756 km² of bamboo forest, in which *Dendrocalamus latiflorus*, *Phyllostachys bambusoides* and Moso Bamboo take 51.7%, 25.6% and 1.9% respectively; next there are a few *Bambusa stenostachya* Hackle, *B. dolichoclada*, and *B. oldhamii*. The harvest can reach 6 million tons every year, including moso bamboo with 300 million culms, about 4.5 million tons (Fangchun 1992). Table 1-1 gives a summary of the species, genera and area of bamboo forest in eight countries. (Lou Yiping,2007; Maxim Lobovikov,2006; Meng Monyrak,1999; Zhongdao 2003).

1.1.2 American region It spans America, covering from 47°S in the South of Argentina in the South up to 40°N of the East of the United States in the North. There are totally around 270 bamboo species in 18 genera, of which 17 genera all consist of monopodial bamboos, except that *Arundinaria Michaux* is a sympodial bamboo (Fangchun 1992). The centers of bamboo distribution are Mexico, Guatemala, Costa Rica, Nicaragua, Honduras, Columbia, Venezuela and the Amazon River Basin in Brazil. From the center of this area south toward to Argentina the bamboo gradually decreases. Bamboo intensively grows in the east of South and North America. The importance of bamboo in culture, production and living is in America far less than in Asia.

Table 1-1 The species, genera and area of bamboo forest in eight countries

Country	Species	Genera	Area in km ²
India	136	19	108,630
Myanmar	100	17	8,950
Thailand	60	13	8,100
Bangladesh	30	13	863
Cambodia	10	4	2,870
Vietnam	101	15	10,000
Malaysia	44	7	5,920
The Philippines	55	12	1,560

1.1.3 African region This region, with less bamboo area, begins at 22°S in the South of Mozambique in the South and ends at 6°N of the East of Sudan in the North. There are totally around 40 species belonging to 13 genera. Within this scope, the distribution center is an inclined bamboo strip from the northwest to southeast spanning tropical rainforest and evergreen broadleaved mixed forest. This strip extends from the South of Senegal at the western seacoast, covering Guinea, Liberia, southern Ghana, Nigeria, Cameroon, Rwanda, Burundi, Gabon, Congo, Zaire, Kenya, Tanzania, Malawi and ends in Mozambique and Madagascar at the eastern seacoast. *Arundinaria alpina* and *Oxytenanthera abyssinica*, with 2300 and 2000 km² bamboo forest respectively, have formed a large area of pure forest or they are found as middle and lower layer in the mixed forest accompanied by other species in the mountains of both Kenya and Ethiopia. The flora of bamboo is less diverse and the level of bamboo exploitation and utilization is lower in the African continent, because there are only about 10 native and introduced bamboo species. In Madagascar however there are 40 species in 11 genera, which is much richer than in the African continent. Therefore the African region can be divided into two sub-regions: the African continent and Madagascar.

1.1.4 Europe, North America and Australia. Bamboo mainly occurs in some countries in Asia, Africa and Latin America. There are no naturally distributed species in Europe, and a few originally distributed species in North America (Yingshuang, 2005). In the past hundred years, England, France, Germany, Italy, Belgium and Holland in Europe, and America, Canada and Australia introduced many bamboo species from Asia, Africa and Latin America. New European, North American and Australian introduced regions have developed. Nowadays bamboo is mostly used in gardening and ornaments, but a production, processing