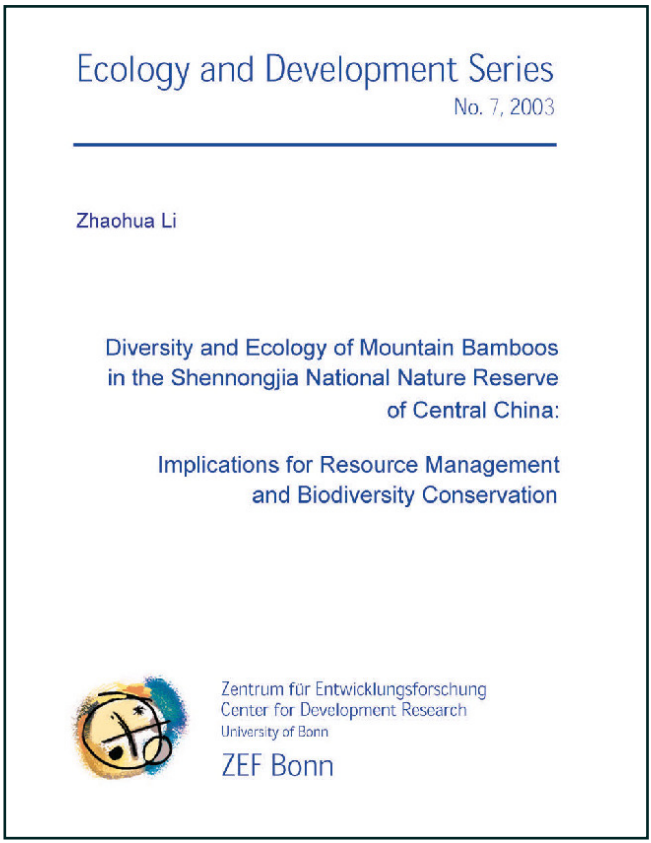
Zhaohua Li (Autor)

Diversity and Ecology of Mountain Bamboos in the Shennongjia National Reserve of Central chiana

Implications for Resource Management and Biodiversity Conservation



1 GENERAL INTRODUCTION

1.1 Background and objectives

Bamboos, ranging from woody to herbaceous taxa, belong to the family *Poaceae* (*Gramineae*), forming the subfamily *Bambusoideae* (Liese 1985; Dransfield and Widjaja 1995). There are approximately 85-90 genera and 1,200-1,500 species of bamboos (Soderstrom et al. 1988; Ohrnberger 1999), native to all continents except Europe and Antarctica (McClure 1993; Liese 2001). They are found especially in Asia and South America, primarily in China (39 genera and 500 species; Zhu et al. 1994; Keng and Wang 1996), India (18 genera and 128 species; Tewari 1992; Seethalakshmi and Kumar 1998), Southeast Asia (20 genera and 200 species; Dransfield and Widjaja 1995), and Latin America (20 genera and 429 species; Londoño 2001). Thirty-two and five species are to be found in Madagascar and Australia, respectively (Wrigley and Fagg 1996; Dransfield 2000), while North America has only one native species, *Arundinaria gigantea* (Walt.) Muhl. (Shor 2002).

1.1.1 Historical importance of bamboo

Before the advent of industrialization and cash-based transactions, bamboo had played a significant role in the self-sustaining economies in many nations that are now grouped together as developing countries (Quintans 1998). For centuries, bamboos have been closely related to agriculture, cottage industries, arts, culture and day-to-day life of more than half of the world's population (Tewari 1992; Quintans 1998; Mohanan 1998; Liese 2001). In southern Asia, bamboo was named "timber of the poor", an inferior substitute for wood products for poor people with low income and purchase power (Liese 1991, 2001). However, bamboo is now used for multifarious purposes such as basketry, weaving, mats, furniture, industrial ply-bamboo panels, flooring materials, papermaking, essential oils and medicines and as nutrition in the form of bamboo shoots (Liese 1985; Dransfield and Widjaja 1995). In fact, very few plant species have inspired such a wide variety of uses as bamboo – quite apart from its role in culture and art, especially in Asia.

China has the richest bamboo diversity in the world in terms of number of species (ca. 500 species) and area of plantation (3.5 million ha, Zhu 1987; Keng and

Wang 1996; Yi 1997). Bamboo played an indelible role in China's self-sustaining economies and traditional cultures for thousands of years. Archaeological evidence suggests that some 5,300 years ago, during the New Stone Age, bamboo had already been used to weave mats, baskets and other articles in eastern China (Wu and Ma 1987). Up to 3,500 years ago, bamboo culms were split into slices for recording and writing, and "books" were made by stringing the bamboo slices together (Zhu 1987); since 1,700 years ago, bamboo has been applied for making paper (Xiao and Yang 2000). Bamboo was so important in Chinese culture and history that when a Prime Minister of the Song Dynasty, Wen Tian Xiang (1236-1282), before he was killed by the Mongol conquerors wrote a poem: "Whoever could be alive without death? But my loyalty will be shining on the bamboo forever", indicating the important role of bamboo in the history of China. Another famous poet, Su Dongpo (1037-1101), wrote, "Meals can be without meat, but living cannot be without bamboo. The lack of meat makes one thin; the lack of bamboo makes one vulgar." He commented: "There are bamboo houses for living, bamboo hats for shading, bamboo paper for writing, bamboo rafts for carrying, bamboo shoes for wearing, bamboo shoots for eating and bamboo fuel for heating. Indeed, we cannot live without bamboos for a single day." This is a succinct summary of the close relationship between bamboo and the Chinese people.

1.1.2 Current role of bamboo

Today, bamboo shows an enormous potential for alleviating many problems - both environmental and social - facing the world (Liese 2001). For example, as a renewable natural resource with the advantage of annual production and growth, bamboo can be a plant that provides a possible solution for the environmental consequences of deforestation in tropical and subtropical regions (Hunter and Wu 2002). In China, in the past two decades bamboo plantation increased by 30 % (Lei 2001), while bamboo exports increased 650 %, from US$ 46.1 million in 1981 to US$ 300 million in 2000 (Lu 2001). Australia has five native bamboo species, but they do not produce edible shoots. Increasing consumption of bamboo shoots in Australia has created a domestic market to the amount of US$ 10-20 million, which completely depends on the import of canned products (Midmore 1997, 1998; Barnes et al. 1999). This situation is stimulating the establishment of bamboo plantations in Australia to supply fresh shoots to replace

imports, and also the development of an export market for fresh shoots to Asian countries during the Northern Hemisphere winter (Midmore 1998; Barnes et al. 1999). Using bamboo as a substitute for timber can save the diminishing rainforests. For example, in Costa Rica, 1,000 bamboo houses are built every year with material coming from a bamboo plantation only 60 ha in size (Adamson and López 2000). If an equivalent project used timber, it would require 500 ha of tropical rainforest.

As a rapidly growing plant, bamboo can contribute to subsequent CO_2 fixation (Scurlock 1999; Liese 2001; Hunter and Wu 2002). One of the most pressing environmental problems of the late twentieth century is the global warming associated with the use of fossil fuels. Kleinhenz and Midmore (2001) estimate the average total biomass of a bamboo stand between 130 and 142 t ha^{-1}; the ability of carbon sequestration from a bamboo plantation is, therefore, nearly as high as that of a forest in middle latitudes. Large bamboos usually have a high primary productivity, e.g., in central Japan, aboveground productivity of a six-year-old clump of *Phyllostachys bambusoides* was reported at 24.6 t ha^{-1} $year^{-1}$ (Isagi 1993); in eastern China, aboveground woody biomass of *Phyllostachys pubescens* increments averaged 7.7 t ha^{-1} $year^{-1}$ (Qiu et al. 1992); in southern India, aboveground productivity of *Bambusa bambos* reached 47 t ha^{-1} $year^{-1}$ (Shanmughavel and Francis 1996). Since bamboo generates a new crop every year, the stands can maintain the ability for fixing CO_2 for as long as 30-120 years without replanting. Based on this concept, bamboo is considered as a new crop. North America has only one native bamboo species, *Arundinaria gigantea* (Walt.) Muhl.; however, to date, about 441 kinds (species, subspecies, varieties, forms, cultivars, and clones) of bamboo have been introduced in the USA since the late 19th century (Shor 2002). Bamboo is considered as a high-potential crop for replacing tobacco in the southeastern United States (Shoch and Stoney 2001), since tobacco cultivation dropped from 831,000 acres in 1992 to 492,300 acres in 2000 and alternative crops are in high demand (USDA 2000). There is no bamboo native to Europe, though it existed naturally in Europe some three million years ago in the Tertiary period but vanished during the ice age (Liese 2001). Since the 19th century, bamboos from China and Japan have been introduced to Europe (Gielis and Oprins 2000). Almost a century ago, over 100 different bamboos were known in Europe, mostly temperate species (Chao 1989). At present, over 400 kinds of bamboo

are grown or cultivated in Europe (Gielis and Oprins 2000). Historically, bamboo was solely cultivated as an ornamental plant in gardens and its ecological and economic values were mostly neglected in Europe. However, an ongoing project, "Bamboo for Europe", is assessing the possibilities of growing and using bamboo in European countries (Gielis et al 1997; Liese 2001).

With numerous rhizomes and evergreen leaves, bamboo is a valuable ally in the fight against soil erosion and water loss (Liese 1991, 2001). The root system of bamboo can create an effective mechanism for watershed protection, stitching the soil together along fragile riverbanks, deforested areas, and in places prone to earthquakes and mud slides (Shoch and Stoney 2001). Bamboo is a pioneer plant and can be grown in soil damaged by overgrazing and poor agricultural techniques. In contrasting to most trees, the bamboo plant is not killed by proper harvesting so topsoil is held in place. Recent research shows that bamboo rhizomes have some associated microorganisms that can fix nitrogen (Wu and Gu 2001) and prevent the soil from acidification (Takamatsu et al. 1997). This indicates that bamboo plantations might be an efficient way of improving degraded land by fixing nitrogen from the atmosphere and increasing soil nutrients.

The increasing importance of bamboo has led to a high demand for bamboo species which could be planted under ecologically and/or economically favorable conditions. The majority of bamboos thrive in the subtropics and tropics, where annual temperatures range from 8.8-36 °C and annual rainfall is above 1,000 mm (Keng and Wang 1996). In the temperate zones of Europe and North America where frost and snow are common, most tropical and subtropical bamboos do not grow naturally. Therefore, cold-resistant bamboos, especially the mountain species, have long been considered as priority for introduction.

1.1.3 Giant panda and bamboo

The conservation of the giant panda (*Ailuropoda melanoleuca*) is a critical issue connected with bamboo occurrence in China. The giant panda is a highly specialized carnivore whose diet consists almost entirely of various species of bamboo. Fossil evidence shows that the giant panda was once widespread in southern and eastern China and in neighboring Myanmar and North Vietnam (Schaller et al. 1985; Taylor et al.

1991; Reid and Gong 1998; Loucks et al. 2001). The panda's range has shrunk considerably in recent history, due to increased human settlement (Schaller et al. 1985; O'Brien et al. 1994; Fong and Li 2001; Liu et al. 2001). By 1800, the giant panda was only to be found in two isolated mountain regions: On the east slope of the Tibetan plateau in central Sichuan and southern Gansu, stretching east to the Qinling Mountains of south-central Shaanxi; and in the hilly country covering southern Shaanxi, eastern Sichuan, western Hubei, and the north western Hunan provinces, with Shennongjia as the highest peak and distribution center (Fongand Li 2001). However, by 1900, the pandas had obviously become extinct in the eastern region, including Shennongjia (Schaller et al. 1985; Reid and Gong 1998).

Bamboo availability has long been considered as a key factor affecting the survival of the giant panda (O'Brien and Knight 1987; Taylor et al. 1991; Fong and Li 2001). Bamboo comprises 99 % of giant panda's diet (Schaller et al. 1985), but of the more than 500 species of Chinese bamboos, the panda favors only about 15 species (Campbell and Qin 1983; Yi 1985; Taylor et al. 1991; Carter et al. 1999). Most of these bamboos (i.e., *Fargesia spathacea*, *F. robusta, F. denudata* and *Bashania fangiana*) are monocarp and flower synchronously at estimated intervals of 30-80 years, depending on the species (Campbell and Qin 1983; Campbell 1987). In the past, when one forage bamboo flowered and died, pandas would normally switch to other species, or expand their home ranges to access areas where the bamboo had not flowered (Schaller 1987; Taylor et al. 1991; Fong and Li 2001; Li and Denich 2001). However, in recent centuries, increasing human settlements and environment changes have made it difficult for the giant panda to reach new food supplies. For example, in 1975-76, three bamboo species flowered synchronously and died in the Min Mountains, where 138 pandas were found dead due to starvation (Schaller et al. 1985; Fong and Li 2001). As at that time, there were only about 1,500 wild pandas in China, the death of so many animals caused widespread concern among government officials and conservationists (Schaller et al. 1985; O'Brien and Knight 1987; Taylor and Qin 1991). Because of the serious problems due to bamboo flowering and environment degradation in panda habitats in Sichuan, the Chinese government proposed removing the starving giant pandas to their historical habitat, Mount Shennongjia in Central China, where there is a plentiful supply of bamboo and there are few human impacts (Cui 1996).