# Bamboo diversity: the need for a Red List review

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**Abstract.** This review focuses on woody bamboos with the highest diversity recorded in the Asia-Pacific region where bamboos play a major role in ecosystem dynamics in many forests. Bamboos are among the least studied of all higher plants since they flower at long intervals and traditional plant taxonomy has relied heavily on floral characteristics. However, DNA sequencing and other new techniques of identification and classification are allowing for some resolution in bamboo phylogeny and systematics. These distinctions are important as domestic trade and subsistence use of 50 to 100 woody bamboo species are estimated to be worth US $ 4.5 billion per year globally. The genetic diversity of the remaining forest bamboos, of which many are highly susceptible to deforestation, is of much greater concern and an accurate information base is required as a foundation for policy and management decisions affecting bamboo. A programme to strengthen the Red List assessments of bamboo species status is also needed, one that prioritizes the assessment of species with the smallest estimated geographical ranges and least remaining habitat.

## INTRODUCTION

Bamboos – some 1200 species in all – are an ancient group of forest grasses that first evolved in the lowland tropics of Gondwanaland between 55 and 70 million years ago. By the mid-Tertiary, as the continental interiors became drier and more open, the grasses as a group of terrestrial plants began their radiation into more open habitats; however, most bamboos either never left the forest habitat or went back to it (Clark 2004). Only a few species occur in open habitats.

The first recognised species of bamboo, *Arundo bambos* (now known as *Bambusa bambos*), was described by Linnaeus in his Species Plantarum (1753). Because traditional plant taxonomy has relied heavily on floral characteristics, and bamboo plants only flower at long intervals (some species have never been observed flowering), bamboos are among the least studied of all higher plants. Names and descriptions developed in the past have been difficult to apply until the bamboos flower again, because they may rely upon floral characteristics for their identification.

A grey bamboo lemur. Photo by Bill Love: www.bluechameleon.org

However, with the arrival of the new techniques of identification and classification, such as DNA sequencing, some progress has been achieved in resolving bamboo phylogeny and systematics. Based on the results of the recent DNA analysis (Zhang 2000), a new classification for bamboos was developed by The Grass Phylogeny Working Group (2001). According to this classification, the subfamily Bambusoideae (of the family Poaceae) includes two tribes, Bambuseae (woody bamboos) and Olyreae (olyroid bamboos). The review contained herein focuses on woody bamboos. Olyroid bamboos (about 100 species) are characteristic of tropical rain forest understoreys and require a separate review.

## BAMBOO IN NATURAL ECOSYSTEMS

The highest diversity of woody bamboos has been recorded in the Asia-Pacific region, with the largest national complement of species in China (more than 600 described species, see Table 1), followed by India (over 100 species) and Japan (over 80 species) (Ohrnberger 1999). The lowest diversity of woody bamboos is found in continental Africa, where five species representing five genera occur. Madagascar with its 33 species of woody bamboos, 32 of which are endemic, is strikingly richer than continental Africa (Bystriakova *et al.* 2004). The low diversity of bamboo species in mainland Africa, compared with Madagascar and other continents, may relate to past climatic variation on the continent, although the precise reasons for it are not known. The Americas are collectively much richer in bamboo species than either continental Africa or Madagascar, but have lower diversity than the Asia-Pacific region. There are approximately 430 species of New World woody bamboos, of which more than 40 % belong to a single genus, *Chusquea* (Judziewicz *et al.* 1999).

In many forest ecosystems bamboos play a major role in ecosystem dynamics. Most bamboo species have distinctive cycles of mass flowering and subsequent die-off that may have evolved as an adaptation to forest fires, and can certainly affect fire cycles. Mass mortality in bamboos after fruiting generates a widespread and synchronous fuel load that significantly increases the potential for wildfire. The resulting canopy disturbance both increases opportunity for seedling recruitment and resets the successional cycle to favour persistence of the new clones. The dense and rapid growth of woody bamboos may suppress the regeneration of other woody species (Clark 1995). This may explain how woody bamboos become dominant in forest ecosystems and can occur in almost homogeneous stands in some places. In northern South America, especially Colombia and Ecuador, the "*guadual*" – dense bamboo forest dominated by *Guadua angustifolia* – is an important

| Country/Territory | Number of naturally occurring species (species without documented distributions in other countries) |
|---|---|
| **Asia-Pacific** | |
| China | 626 (583) |
| India | 102 (40) |
| Japan | 84 (75) |
| Myanmar | 75 (30) |
| Viet Nam | 69 (38) |
| Indonesia | 56 (29) |
| Malaysia | 50 (26) |
| Thailand | 36 (4) |
| Philippines | 26 (14) |
| Nepal | 25 (6) |
| Papua New Guinea | 22 (15) |
| Bhutan | 21 (1) |
| Bangladesh | 18 (0) |
| Laos | 13 (4) |
| Sri Lanka | 11 (6) |
| Hong Kong | 9 (3) |
| Brunei | 6 (1) |
| Korea, Republic of | 6 (2) |
| Cambodia | 4 (0) |
| Australia | 3 (2) |
| Pakistan | 3 (0) |
| Singapore | 3 (0) |
| Korea, DPR | 2 (0) |
| Russia (Sakhalin& Kuril Isls) | 1 (0) |
| **Continental Africa and Madagascar** | |
| Madagascar | 33(32) |
| Tanzania | 4 (1) |
| Malawi | 3 (0) |
| Uganda | 3 (0) |
| Zambia | 3 (0) |
| Cameroon | 2 (0) |
| Congo | 2 (0) |
| Democratic Republic Congo | 2 (0) |
| Ethiopia | 2 (0) |
| Sudan | 2 (0) |
| Zimbabwe | 2 (0) |
| Angola | 1 (0) |
| Benin | 1 (0) |
| Burundi | 1 (0) |
| Central African Republic | 1 (0) |
| Comoro Islands | 1 (0) |
| Côte d'Ivoire | 1 (0) |
| Eritrea | 1 (0) |
| Gambia | 1 (0) |
| Ghana | 1 (0) |
| **Continental Africa and Madagascar (cont'd)** | |
| Guinea | 1 (0) |
| Guinea-Bissau | 1 (0) |
| Kenya | 1 (0) |
| Lesotho | 1 (1) |
| Mozambique | 1 (0) |
| Nigeria | 1 (0) |
| Rwanda | 1 (0) |
| Senegal | 1 (0) |
| Sierra Leone | 1 (0) |
| South Africa | 1 (1) |
| Togo | 1 (0) |
| **North, Central and South America** | |
| Brazil | 134 (110) |
| Venezuela | 68 (32) |
| Colombia | 56 (15) |
| Ecuador | 41 (14) |
| Costa Rica | 36 (13) |
| Peru | 35 (15) |
| Mexico | 32 (17) |
| Bolivia | 20 (2) |
| Panama | 19 (1) |
| Chile | 14 (10) |
| Cuba | 13 (6) |
| Argentina | 12 (2) |
| Guatemala | 12 (0) |
| Honduras | 8 (0) |
| El Salvador | 7 (1) |
| Haiti | 7 (0) |
| Nicaragua | 7 (0) |
| Trinidad and Tobago | 7 (2) |
| Dominican Republic | 6 (0) |
| Paraguay | 6 (1) |
| Guyana | 5 (2) |
| Puerto Rico | 5 (0) |
| Uruguay | 5 (1) |
| Suriname | 4 (0) |
| Belize | 3 (1) |
| Bahamas | 1 (0) |
| Dominica | 1 (0) |
| French Guiana | 1 (0) |
| Guadeloupe | 1 (0) |
| Jamaica | 1 (0) |
| Martinique | 1 (1) |
| United States | 1 (1) |
| Virgin Islands | 1 (0) |

Table 1.
Numbers of species of woody bamboos occurring in the countries of the Asia-Pacific region, Africa and Madagascar, and the Americas
Source: Ohrnberger 1999

vegetation type at low to mid-altitude. Bamboo-dominated areas in the Amazon region occupy between 121,000 and 180,000 km$^2$ (Nelson 1994; Judziewicz *et al.* 1999). This vegetation, which is dominated by bamboos of the genera *Guadua, Elytrostachys* and


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Valerie Kapos conducted research on various aspects of tropical forest ecology in Latin America and the Caribbean, including the effects of forest fragmentation in Amazonia. Since 1994 she has been working with UNEP's World Conservation Monitoring Centre (UNEP-WCMC) and other conservation organisations, applying her ecological knowledge to conservation policy and practice through the use of biodiversity indicators.

*Arthrostylidium*, is often impenetrable because of the thorns of the bamboo. In some areas, woody bamboos have become invasive and dominate forest succession in abandoned cultivation, excluding the regeneration of native tree species (WWF 2003).

Bamboo flowering and subsequent mast seeding is associated with explosive increases in population abundance or density of rodents, or so-called "*ratadas*" (Gallardo & Mercado 1999; Jaksic & Lima 2003). *Ratadas* are usually associated with famine, calamities and increase in diseases in local population. In India, the most recent plague of rats that followed mass flowering of the local bamboo *Melocanna bambusoides*, triggered a civil unrest in the north-eastern state of Mizoram (Banik 2004).

## BAMBOO AND DEPENDENT SPECIES

While some take advantage of the irregular bamboo mast seeding events, many forest animals depend on bamboo in their day-by-day life. Many of these are of conservation concern and considered by IUCN to be under threat. In Asia, "Endangered" Giant Panda (*Ailuropoda melanoleuca*) and Red Panda (*Ailurus fulgens*) are totally dependent on a few species of bamboo; the "Vulnerable" Himalayan Black Bear (*Selenarctos thibetanus*) often feeds on bamboo shoots in summer.

For the 650 or so "Endangered" Mountain Gorillas (*Gorilla beringei beringei)* that still remain in the wild in Central Africa, bamboo shoots can make up as much as 90 % of their diet. The Eastern or Mountain Bongo (*Tragelaphus euroceros* ssp. *Isaaci*) of the Aberdare Mountains in Kenya is one of the world's most endangered mammals, with fewer than 100 individuals remaining in the wild. This large forest antelope spends the wet season in cloud forests lower down the mountains, but migrates to spend the dry season in the dense thickets of bamboo (*Yushania alpina*) 1000 meters up the slopes.

In Madagascar, all three recognized species of bamboo lemur (two of them, *Hapalemur simus* and *H.aureus*, are classed by IUCN as "Critically endangered") heavily depend on bamboo, various parts of which make up a large part of their diet. The bamboo forests in the drier western part of Madagascar are the habitat of one of the most endangered reptiles in the world, the Ploughshare Tortoise (*Geochelone yniphora*).

In South America, especially at higher altitudes and in the Atlantic forest zone, several endangered mammals feed on bamboo. The Spectacled Bear (*Tremarctos ornatus*), classified as "Vulnerable" by IUCN, feeds opportunistically on young shoots of bamboo. "Endangered" Mountain Tapirs (*Tapirus pinchaque*) eat considerable amounts of bamboo in their high-altitude habitats. Of the 27 Atlantic Forest bird species associated with bamboo, 11 are of conservation concern (Haemig 2003).

A number of less charismatic animals also depend on bamboo. Some use bamboo for shelter or escape from potential predators, some for reproduction. One of the world's smallest bats (*Tylonycteris pachypus*) recently discovered in Hong Kong, just 3.5 cms. long, roosts between nodes of mature bamboo, which it enters through holes created by beetles. A species of poison frog (*Mantella laevigata*) endemic to north-eastern Madagascar breeds in water-filled tree holes of broken bamboo. North American canebrakes, dense stands of *Arundinaria gigantea*, much reduced by development, drainage and suppression of the fire regime that was important to their maintenance, still provide shelter for at least five species of butterfly, which require the cane as food during the caterpillar stage.

## BAMBOO CULTURE

Throughout the world, people have fashioned more than a thousand different products from bamboo stems and leaves. Worldwide, domestic trade and subsistence use of bamboo are estimated to be worth US $ 4.5 billion per year. Global export of bamboo generates another US $ 2.7 billion (INBAR 1999).

Bamboo culture is deeply rooted in the life of people in South Asia. Bamboos can supply virtually the entire needs of a rural community, providing strong stems for building houses and bridges, as well as furniture, water pipes and musical instruments. For centuries, bamboo plants have been a source of inspiration for poetry, art and philosophy. Today, bamboos are growing in commercial importance, as modern manufacturing techniques transform bamboo into flooring and board products, laminates and furniture. Bamboo is becoming a substitute for wood in pulp and paper manufacturing. In 1998, about 25 % of the fibre used in the Indian paper industry came from bamboo (FAO 1998). China, with its traditional bamboo culture, is also the world's most important producer and exporter of bamboo shoots, poles and furniture.

In Africa, although there is little cultivation of bamboo and little or no international trade in bamboo, many bamboo products are used domestically and can be very significant in both household and local economies. Key bamboo uses include small-scale construction, handicrafts, residential fencing, horticultural flower farming, water pipes, farm props for banana plantations, furniture, and other minor cottage industry products like basketry and toothpicks. In some parts of Africa, bamboo is also a source of food and drink. In Tanzania and Uganda young shoots and seeds of *Oxytenanthera abyssinica* are consumed as food. The principal use of this species in Tanzania, however, is in the production of bamboo wine, also known as *ulanzi*. Tips of young shoots are cut off and the stem portion bruised every morning and evening for about a week. The exudates from the bruises is collected and allowed to stand for two days to ferment. The resulting *ulanzi*, 5-5.5 per cent alcohol, is one of the principal forms of alcohol consumed in some areas.

South American bamboos. (Photos courtesy of INBAR)

Bamboos are a source of food both for humans and for livestock in the Americas, though to a much lesser extent than in Asia or Africa. Indigenous Peoples eat the fruits and seeds of several species, and some use of bamboo shoots as food has been reported. Woody bamboos are also used to make handicrafts and musical instruments. Baskets, fans, utensils, toys, furniture and agricultural supports are all made from bamboo of different types. Bamboo has a long history of use in construction in Central and South America, where it is a common part of the vernacular architecture. In southern Colombia and northern Ecuador, bamboo (mostly *Guadua angustifolia*) has been extensively used in houses that have stood for 50-100 years on unstable sites such as steep slopes, earthquake-prone regions, or swampy coastal areas that are frequently inundated. More than 100,000 ha of *Bambusa vulgaris* introduced from Asia are cultivated for paper production in Brazil, which is the only New World country to use bamboo for making paper (Judziewicz *et al.* 1999).

## CONSERVATION STATUS OF FOREST BAMBOOS

So far, between 50 and 100 woody bamboo species are exploited by major industries and have been domesticated into plantations. Actively cultivated locally for millennia, these species are in a relatively secure position, at least in terms of their genetic diversity. Of much greater concern in terms of erosion of their genetic diversity are the remaining forest bamboos, of which many are highly susceptible to deforestation. With the annual loss of forest of up to 0.8% (over 5 million ha per year) in tropical Africa and 0.4% (nearly 4 million ha per year) in South America (FAO 2001), many woody bamboos are potentially threatened if they depend on forest habitat for their survival. According to the results of a recent study (Bystriakova *et al.* 2003a, Bystriakova *et al.* 2003b, Bystriakova *et al.* 2004), as many as half of the world's woody bamboo species may be vulnerable to extinction as a result of massive forest destruction. Some 250 woody bamboo species have less than 2000 $km^2$ of forest – an area the size of London – remaining within their ranges.

Although some bamboos have been the subject of a great deal of research, the majority of species are poorly known and much of their biology is incompletely understood. Most international research funding and effort has focused on a relatively small set of 38 "priority species" of bamboo that are commercially important and widely distributed. Of these, most are native to the Asia-Pacific region, one is and African species and one comes from South America (Rao *et al.* 1998).

The vulnerability of some species is increased by the simultaneous flowering and subsequent death of entire populations in cycles of 20-120 years. If a single regeneration event coincides with unsuitable conditions such as high grazing or fires, the entire



A & B. Bamboo bridge (Photos by Joerg Stamm)

population might lose its chance to reproduce. Because bamboo seed is produced infrequently and can in many cases be stored for only a few years (Stapleton and Rao 1996), *in situ* conservation efforts are needed to complement the current emphasis on conservation through seed storage.

At present, official conservation assessments of bamboos contrast markedly with the results of the map-based studies. Currently, the IUCN Red List of "Endangered" bamboos comprises 20 American, 16 Asian and one African species (Gillet and Walter 1998). Although 25 of the Madagascan species probably have less than 20,000 km$^2$ of forest remaining within their ranges and as many as ten species have less than 2,000 km$^2$ for forest available to them, none of Madagascar's woody bamboos is currently listed by IUCN as a plant species of global conservation concern.

## CONCLUSIONS

Significant effort is still required to assemble an accurate information base as a foundation for policy and management decisions affecting bamboo and to ensure the survival of their full biological diversity. A programme to strengthen the Red List assessments of bamboo species status is needed, one that prioritizes the assessment of species with the smallest estimated geographical ranges and least remaining habitat.

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