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Distribution and conservation status of forest bamboo biodiversity in the Asia-Pacific Region

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Abstract. Although Asian bamboo species constitute a non-timber forest product of major cultural and economic importance, no detailed regional assessment of their distribution patterns has previously been made. To assess the potential of the existing bamboo species distribution data for production of regional mapping tools for planning the conservation of forest-based biodiversity, data on bamboo distribution and forest cover were combined. Over 1000 bamboo species from 60 genera of woody bamboos were incorporated, allowing the mapping of individual species or groups of species and genera, along with potential species richness and biodiversity hotspots. Over 6.3 million km^2 of Asian forest potentially contains bamboo, with highest densities indicated from northeastern India through Burma to southern China, and through Sumatra to Borneo. The highest figures for potential species richness (144 spp per square km) were recorded in forests of south China, including Hainan Island. Despite substantial inadequacies and inconsistencies in knowledge of the taxonomy and distribution of bamboo species, this approach may provide a valuable tool for planning *in situ* conservation of forest biodiversity.

Introduction

Bamboos play an important role in local economies throughout the world and are of major national and international commercial importance in the Asia-Pacific region (INBAR 1999). It is estimated that 2.5 billion people depend on or use bamboo materials valued at US$ 7 billion per annum (Banik 1995). Bamboos are traditionally important in supplying housing, tools and other implements, musical instruments and other handicrafts (McClure 1966). Due to modern technological advances bamboos have become important in world markets in the form of pulp for paper, parquet, plybamboo and as a canned vegetable (Dransfield and Widjaja 1995). They are also of great conservation significance because of their own diversity and because of the species that depend on them, the best known being the Giant Panda (Schaller et al. 1985; McNeely 1996).

Despite the economic, social and conservation significance of bamboos, data on bamboo distribution and resources, especially in natural forests, are very limited. Classified as a 'non-timber forest product', bamboo is not routinely included in

resource inventories, whether agricultural or forest-related. Compilation of reliable data on species and their distribution patterns is hampered by inadequate bamboo classification systems and nomenclature, and poor documentation of species characteristics. As a result, detailed, transparent, and comprehensive estimates of bamboo resources are lacking for nearly all Asian countries.

Until recently, resources for bamboo research and biodiversity conservation have been targeted on a set of 38 'priority species' that are widely distributed and commercially important (Williams and Ramanatha Rao 1994; Dransfield and Widjaja 1995; Ramanatha Rao and Rao 1995; Ramanatha Rao 1998). The justification for the concentration of resources on such a narrow range of the most common species was the assumption that future increases in productivity would be based on infra-specific genetic improvement (Williams 1998). However, there has so far been little progress in selective breeding in these plants, which only flower at intervals of up to 150 years.

Expanding conservation of bamboo diversity to other species requires that the use of available resources is focussed appropriately, and this in turn requires a sound knowledge of the distribution and status of a wide range of forest bamboo species. Many of these species are highly productive and useful, but they are poorly studied and often vulnerable (Messerschmidt et al. 2001). Protection of their natural populations *in situ* is imperative, as *ex situ* conservation techniques are currently not practical for bamboos (Stapleton and Rao 1996). Bamboo seed is infrequently produced and has poor viability, and plantations are difficult to raise and protect on a large enough scale. While *in situ* conservation is currently the only option, many bamboo habitats are threatened by deforestation and changing forest management patterns.

As a first step towards improving conservation planning and action for bamboos, the International Network for Bamboo and Rattan (INBAR) and the UNEP World Conservation Monitoring Centre (UNEP-WCMC) have initiated a project to improve the information available on the magnitude and distribution of bamboo resources within remaining forested areas and the distribution of forest likely to contain threatened bamboo species. In the first stage of the project, we compiled information on the distribution of bamboo species in the Asia-Pacific region, including threatened ones, and combined these data with the regional data on remaining forest cover to map their likely present distributions and estimate the total area of forest potentially containing bamboo. Maps showing regional patterns of potential bamboo species and generic richness have been generated to support decision making on forest management and conservation.

Scope of the study and methodology

The subfamily Bambusoideae (of the family Poaceae, or Gramineae) comprises both woody and herbaceous bamboos, with altogether nearly 1500 species (Ohrnberger 1999). This study was confined to woody bamboos, as these are most important from the socio-economic point of view, and focuses only on the seven subtribes and 60 genera occurring in the Asia-Pacific region (23 Asian countries plus the Russian

Sakhalin and Kuril Islands) (Appendix 1). Only those species that occur naturally (i.e. could be associated with the existing forest cover) in the forests of the Asia-Pacific region were included. We gathered data on 998 species that occur naturally in the region.

For each species bibliographic sources were searched to acquire data about its distribution. These data were principally political units (country, province, locale), altitudinal range and forest type. The data were entered into an Access database containing 13 fields and multiple records for each species (a total of 2190 records). For some species and locations the information available in the bibliographic sources was more detailed than for others: only 980 records (45%) contain information about altitudinal range, while 1846 records (84%) have data about species distribution on the provincial level.

Six fields from the database were used to generate individual species potential distribution map grids in ArcView. Individual grids were shaped according to the information about species' natural distribution on the country and province levels and altitudinal range (minimum and maximum altitude) available in bibliographic sources. Data on the distribution of existing forest cover (UNEP-WCMC 2000) were used as a mask to eliminate areas that are not currently forested. In cases where there was no information about distribution of a species within the country, the whole country was regarded as a smallest distribution unit. When multiple data on altitudinal range existed for the same species, the broadest range was applied.

With this approach, the potential current distributions of 998 individual bamboo species were mapped on 1 km^2 grids using ArcView. The individual species grids were used to assess the total area of potential occurrence for each species. They were also sorted and merged by genus, and were combined individually to generate a potential species richness map for the whole region.

Results

Among the countries of the Asia-Pacific region, China has the largest national complement of bamboo species (626 described species), followed by India (102 species) and Japan (84 species) (Table 1).

There was great variation in the current extent of occurrence among bamboo species. Some species are apparently confined to a few tens of square kilometres of forest, while the widest ranging appear to encompass more than 2 million km^2 of forest within their distributions. While some of the species with the most limited extents of occurrence are poorly known and may not be taxonomically valid, there are nearly 450 species that have less than 20 000 km^2 of forest within their ranges (Figure 1).

Integration of 998 species distributions in a single regional map of potential bamboo species richness (Figure 2) shows that over 5.3 million km^2 of forest in the Asia-Pacific region potentially contains bamboo. The maximum potential species richness in the region was recorded for a total area of about 900 km^2 in southern China, where 144 species distributions overlapped. More than 38% (2.4 million km^2) of the total area of forest potentially containing bamboo has potentially from 1

Table 1. Numbers of species of Bambuseae occurring in the countries of the Asia-Pacific region (Ohrnberger 1999).

Country	Number of naturally occurring species
Australia	3
Bangladesh	18
Bhutan	21
Brunei	6
Cambodia	4
China	626
Hong Kong	9
India	102
Indonesia	56
Japan	84
Laos	13
Malaysia	50
Myanmar	75
Nepal	25
North Korea	2
Pakistan	3
Papua New Guinea	22
Philippines	26
Russia (Sakhalin and Kuril Islands)	1
Singapore	3
South Korea	6
Sri Lanka	11
Thailand	36
Vietnam	69
Total species in all countries	1012

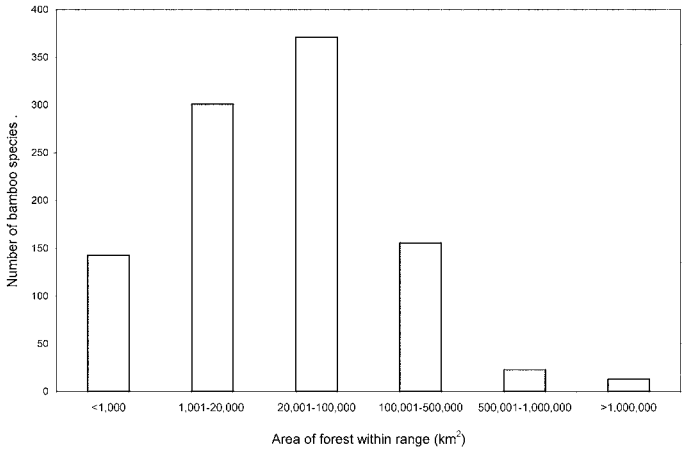

Figure 1. Numbers of bamboo species by area of forest occurring in their potential extent of distribution. The extents of distribution were mapped for each species using bibliographic information on political units, elevation and ecological preferences.

to 5 species (Figure 3), while a potential richness of more than 50 species was recorded for 221000 km^2 (3.5% of the regional total).

The maps of genus distribution generated from the species maps show that the 60 genera of Bambusoideae within the region range from widely distributed (e.g. *Bambusa*) to nationally endemic (e.g. *Sasaella*). Most genera were distributed across several countries, but not the whole region. The pattern of potential generic richness in the region is geographically similar to that of potential species richness, with a maximum generic richness of 22 genera found in southern China. About a quarter of the bamboo-containing forest of the Asia-Pacific region potentially contains one to two genera (Figure 4).

Discussion

The results of this study contribute to an understanding of where bamboo is most likely to be a significant component of forest biodiversity. In conjunction with

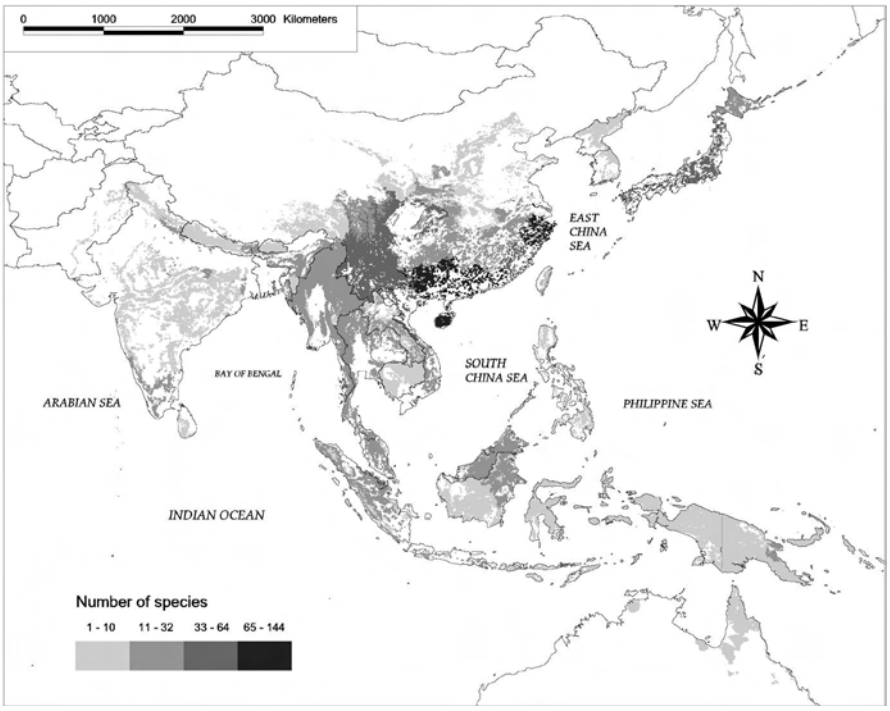

Figure 2. Map showing the potential distribution of total species richness of woody bamboos in forests of the Asia-Pacific region. The map was compiled by overlaying distribution maps for 998 individual species. These were derived for each species using bibliographic information on political units, elevation and ecological preferences, mapping these and using UNEP-WCMC data on forest cover to eliminate all non-forest areas.

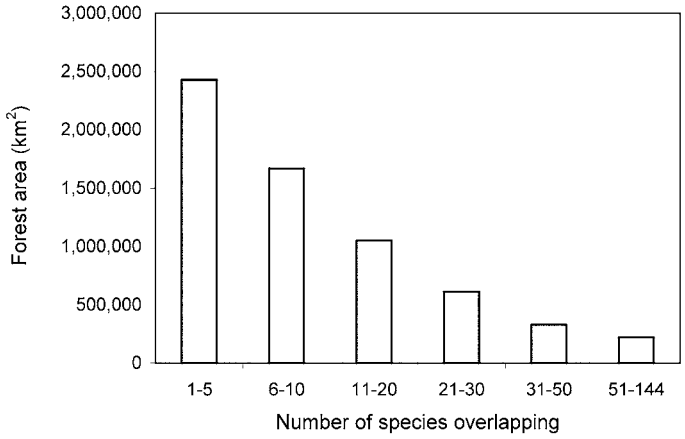

Figure 3. Total area of the Asia-Pacific region covered by forest in each potential bamboo species richness class. The classes refer to the number of species whose distributions overlap in each 1 km^2 cell of the ArcView grid.

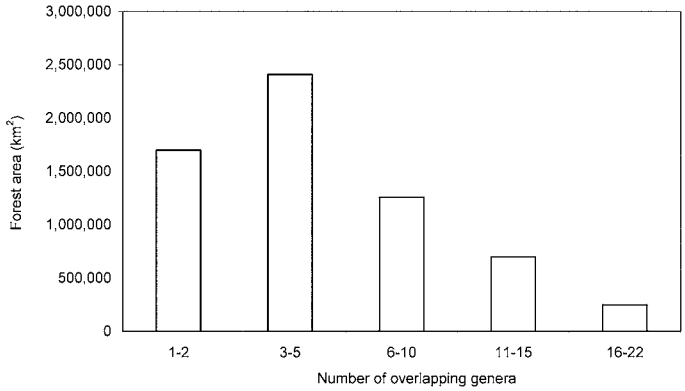

Figure 4. Total area of the Asia-Pacific region covered by forest in each potential bamboo generic richness class. The classes refer to the number of genera whose distributions overlap in each 1 km^2 cell of the ArcView grid.

knowledge of deforestation and practicalities of implementing biodiversity and conservation activities, they constitute a useful planning tool.

Our results show that a number of bamboo species in the Asia-Pacific region apparently have very limited areas of remaining habitat. The criteria for assigning species to IUCN's Red List categories of extinction risk (IUCN 2001) specify that species with a geographical 'extent of occurrence' smaller than 20 000 km^2 may be classed as vulnerable or at higher risk of extinction, depending upon additional information. Although the areas of potential occurrence mapped for each species in this study differ from the extent of occurrence as defined by the IUCN (2001), the

results do suggest that nearly 450 woody bamboo species may be of conservation concern. Data like these can be used to inform the detailed evaluation of species conservation status and can also play a useful role in prioritising the effort devoted to such assessments.

Not surprisingly, given its dependence on bibliographic information, the regional overview of bamboo species richness provided by this study (Figure 2) supports current understanding of bamboo distribution, with the main centres of diversity being the monsoon-belt of southeast Asia and southern China (Ohrnberger 1999). The highest diversity of bamboos is found in the Guangxi, Guangdong, and Hainan provinces in southern China, where climatic conditions are ideal for bamboos and a large elevational range provides a variety of habitat types. The magnitude of diversity recorded for this region probably reflects intense research efforts prompted by the economic and social importance of bamboos there. On the other hand, low diversity elsewhere, especially in bordering countries, indicates that the observed patterns may be in part due to variable research effort.

It is important to recognise that many bamboo species persist outside forest, and the study did not address this. Therefore, apparent absence of bamboo in some countries, especially those that have been severely deforested (such as Bangladesh), reflects the scarcity of forest habitat and may not indicate a complete absence of bamboo.

The regional overview also provides one basis for geographic prioritisation of efforts to conserve biodiversity of bamboos. Conservation of bamboo diversity is important economically as well as in conservation terms, because loss of diversity in bamboo species can lead to major disruption of supplies, whether poles for construction or food for wildlife, since gregarious flowering of any one species will disrupt the supply more as the number of species declines. The limited areas where more than 50 species distributions appear to overlap correspond to around 1% of all the forest cover of the region (FAO 2001). For improved conservation planning it will be necessary to consider both these areas and the distributions of individual species of conservation concern, and determine as priorities those areas that best address both sets of data.

A number of factors mean that this study must be considered a first approximation. Firstly, it reflects the present level of easily accessed knowledge about taxonomy and distribution of Bambusoideae in the Asia-Pacific region (principally Ohrnberger 1999). The more detailed information that is to be found in more dispersed and less accessible literature is often out of date in terms of modern bamboo taxonomy and modern geo-political units. Secondly, the lack of ecological information and location details in many species descriptions meant that the boundaries of unduly large administrative units often had to be used for species mapping. This resulted in higher overlap of species than may be the true case, so that the absolute figures for potential species richness are rather high, and the areas with very high richness should be correspondingly smaller.

As well as providing information from which to plan conservation strategies, the maps may also constitute a first step in quantifying national, regional, and global forest bamboo resources more effectively. Future work in this area will require a

number of types of improved information, including progress in bamboo taxonomy and forest inventory data sets that include bamboo.

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Appendix 1

Subtribes and genera of woody bamboos occurring naturally in Asia (after Ohrnberger 1999).

Subtribe	Genera
Arundinariinae	Arundinaria, Acidosasa, Bashania, Ferrocalamus, Gelidocalamus, Indocalamus, Metasasa, Oligostachyum, Pleioblastus, Sasa, Sasaella, Vietnamocalamus, Pseudosasa
Thamnocalaminae	Ampelocalamus, Borinda, Chimonocalamus, Drepanostachyum, Fargesia, Himalayacalamus, Thamnocalamus, Yushania
Racemobambosinae	Neomicrocalamus, Racemobambos, Vietnamosasa
Shibataeinae	Brachystachyum, Chimonobambusa, Hibanobambusa, Indosasa, Phyllostachys, Semiarundinaria, Shibataea, Sinobambusa
Bambusinae	Bambusa, Bonia, Dendrocalamus, Dinochloa, Gigantochloa, Holttumochloa, Kinabaluchloa, Klemachloa, Maclurochloa, Melocalamus, Pseudobambusa, Pseudoxytenanthera, Sinocalamus, Soejatmia, Sphaerobambos, Thyrsostachys
Melocanninae	Cephalostachyum, Davidsea, Dendrochloa, Melocanna, Neohouzeaua, Ochlandra, Pseudostachyum, Schizostachyum, Teinostachyum
Hickeliinae	Hickelia, Nastus, Temburongia

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