

# Biodiversity and bamboo genetic resources in Asia :*in situ* , community-based and *ex situ* approaches to conservation<sup>\*</sup>

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## 亚洲的生物多样性及竹类遗传资源 :就地保护、社区保护和易地保护

“ Their strength , lightness , smoothness , straightness , roundness , and hollowness , the facility and regularity with which they can be split , their many different sizes , the varying length of their joints , the ease with which they can be cut and with which holes can be made through them , their hardness outside , their freedom from any pronounced taste or smell , their great abundance , and the rapidity of their growth and increase , are all qualities which render them useful for a hundred different purposes , to serve with other materials which require much more labour and preparation. The bamboo is one of the most wonderful and most beautiful productions of the tropics. ” ( Alfred Russel Wallace , 1869 ).

### 1 INTRODUCTION

Bamboo is an extremely useful grass which is in high demand throughout Asia , with a commercial economic value of about US \$ 7 billion per year ( Stevens , 1995 ). Because of the bulkiness of bamboo culms and the high freight/value ratio of bamboo , the radius of economical transport is limited so most bamboo is used near the centres of production. Even so , Liese ( 1985 ) reports that in 1979 Taiwan alone exported bamboo and goods made from bamboo to more than 80 countries , earning about US \$ 116 million.

Bamboo is the most diverse group of plants in the grass family , as well as forming the most primitive sub-family. They are distinguished by having woody culms and complex branching , a complex and generally robust rhizome system , and infrequent flowering ( Soderstrom and Calderon , 1979 ). Bamboo has a cosmopolitan distribution , ranging from 46 to 47 latitude , reaching elevations as high as 4000 m in the Himalayas and parts of China. Bamboo is very adaptable , with some species being deciduous and others evergreen ; although at least some species seem to be able to change this habit when necessary.

While bamboo is widespread , it is seldom collected by botanists because they flower rarely and are very cumbersome to collect ; taxonomically critical vegetative parts such as new culm leaves and branch complements also need to be sampled if the collection is to be taxonomically helpful. Thus the taxonomy of bamboo remains relatively poorly understood , though a general consensus seems to be that bamboo numbers over 60 genera and 1500 species ( Dransfield , 1988 ).

Bamboos are often divided into cultivated or village bamboos and native or forest bamboos ( Hottum , 1958 ). Native bamboo tends to be a plant of the secondary forest ; in Sumatra , patches of

bamboo in the forest almost invariably indicate sites disturbed intensively by people at some time in the past ( Whitten , et al. , 1984 ). In Borneo , cultivated bamboos are found only in localities once under cultivation or near habitations , and indeed various species have been introduced by forest-dwelling people who value their presence ( Beccari , 1904 ). Bamboo seems to have followed many ancient maritime spice routes between China , Indonesia , Sri Lanka and India , sometimes making it difficult to establish the centre of origin for some species ( Soderstrom and Calderon , 1979 ).

Bamboo is difficult to hybridize since its flowers are monocarpic and most species flower gregariously at long periodic intervals ( 60 ~ 120 years ) ; this helps explain why propagating bamboo by seeds is not very popular. While vegetative propagation is possible , it is seldom practised in captivity.

Bamboo can meet industrial and rural requirements , check erosion , and conserve soil. It can be directly sown or planted as rhizomes , culm cuttings , or nursery-raised seedlings. Because of its extensive rhizome and root system , bamboos are useful for soil erosion control and road and stream embankment stabilization. Bamboo can be extremely important in providing vegetative cover to deforested areas. It produces a leafy mulch on the soil surface , its foliage provides shade and protection against rains , and its habit of producing new culms from rhizomes enables the culms to be harvested without disturbing the soil ( Soderstrom and Calderon , 1979 ).

Bamboo forests may yield more raw material more quickly for rural people than do forests , even some types of forest plantations. Some species of bamboo produce annual yields of over 10 t/hm<sup>2</sup> , though Liese ( 1985 ) concludes that the sustainable yield can generally be assumed to be 2 ~ 4 t/hm<sup>2</sup> as understorey and 5 ~ 12 t/hm<sup>2</sup> from plantations , with higher values on good soils with scientific management aided by fertilizers. While bamboo historically has been so common that no particular management was considered necessary , increasing demands from the rural population , urban centres , and international trade are leading to declining stocks and increasing concern about conservation. On the other hand , its multiple uses can provide a basis to create incentives for its conservation in support of development. This paper will review the cultural and biological importance of bamboo to demonstrate why its conservation is important , outline some of the conservation steps that are being taken , and recommend additional steps to be taken.

## 2 CULTURAL VALUES OF BAMBOO

Porterfield ( 1933 ) suggested that " bamboo is one of those providential developments in nature which , like the horse , the cow , wheat and cotton , have been indirectly responsible for man's own evolution ". In many parts of Asia , life symbolically starts with bamboo , as a bamboo knife is used to slice the umbilical cord of newborn babies. Bamboo also plays a role in some rites of passage ; for example , in Malaysia , a bamboo knife is used for performing circumcision ceremonies ( Skeat , 1900 ). Life can also end with bamboo , as it has been converted into numerous kinds of weapons , ranging from the infamous punji sticks which were used in the Vietnam war as a sort of biological landmine , to arrows , spears , and other weapons.

In China , bamboo is one of the four noble plants , the others being the orchid , the plum tree and the chrysanthemum. Sharma ( 1982 ) reports that 800 years ago the Chinese poet Pou Sou-Lung wrote : " A meal should have meat and a house should have bamboo. Without meat we become thin , without bamboo we lose serenity and culture itself ". Bamboo may have stimulated new ways to approach old problems in China. For example , it is widely believed that the early Chinese ship builders derived the concept of the water-tight bulkhead from the natural internal walls in the nodes of the bamboo stem. Bulkheads were fitted in Chinese junks 2000 years before they appeared in the West.

Bamboo also serves shipping as ropes and cables which are of great tensile strength , highly resistant to rot , chafe , and stretch , and relatively light to handle. Bamboo is also woven into screens and roofing mats for the deck housing , as well as providing various booms and poles.

It is not surprising that such an important resource is sometimes given ceremonial value. In Bali , for example , " bamboo is considered an extremely powerful plant. Only old people may tackle the dangerous job of planting it or digging it out , and the first lump of earth dug must be thrown as far away as possible. It is said that if this earth touches someone , he will surely die , and it is only on certain days that work concerning bamboo may be safely undertaken" ( Covarrubias , 1937 ).

The Torajas of Sulawesi believe their ancestors came from mainland Southeast Asia , so their houses are sited facing north and are built in the shape of the boats in which their ancestors are believed to have sailed. The houses are tall and narrow , with walls often built with bamboo and a roof of split bamboo rods covered by thatch.

The meeting houses of some New Guinea villages are 20 m tall and more than 40 m long , with huge bamboo poles set deep into the ground and bent over in the shape of gothic arches to carry the thickly thatched roof , creating some of the boldest structures built with minimal equipment and technology. Japanese houses are far more sophisticated , but are still typically built of wood , paper , and bamboo.

However , bearing out the adage that the value of a resource depends on how it is used , bamboo sometimes has led to significant economic loss to some Asian countries. In 552 A. D. , the eggs of the silkworm were first smuggled by monks in bamboo sticks from China to Constantinople , which led to the collapse of the profitable Chinese silk trade ( Liese , 1985 ).

## 2.1 Bamboo and the arts

In the rich art of China and Japan , bamboo provides the paper , the brush , and the artist's subject. Some of the fine brushes used in Chinese paintings are made of fine bamboo shavings with a small holder of bamboo.

Bamboo is widely used for musical instruments of three types , percussion or hammer instruments , blown or wind instruments , and stringed instruments. More than 20 musical instruments in West Java are made from bamboo. The flute may have been invented by a caveman toying with hollow bamboo ; at any rate , bamboo flutes are an ancient feature in Southeast Asia , as they are known to every indigenous group in the region ( Widjaja and Dransfield , 1989 ). Bamboo provides both tubes and reeds for flutes , ranging from simple tubes to complex pan-pipes ; the famous bamboo organ at Las Piñas in the Philippines was constructed in 1818 from 950 bamboo culms , and is still in use ( though some of the culms have been replaced ). A percussion instrument used in Indonesia and Thailand is based on hollow bamboo sound tubes tapped by moving hammers which are extended up and have peacock feathers at the end ; shaking the instrument causes the tapping note. A sort of xylophone widely used in Southeast Asia is made of segments of bamboo of different lengths strung together to produce the notes of the scale and played with two sticks. Not all bamboo instruments need such energy ; in some villages , bamboos are carved so that breezes blowing through the perforations produce melodious musical tones , often of great complexity ( Kurz , 1876 ).

Orang Asli in Malaysia make beautifully incised and decorated combs from pieces of split bamboo. Many of these combs are rightly considered works of art , and some of them have certain ritual connotations , protecting the individual against evil spirits ( Carey , 1976 ). For many of the native peoples of Borneo , the working of designs on the surface of pieces of bamboo is an important expression of their artistic abilities , decorating their drinking cups , tobacco boxes , and tubes for carrying flint and steel. Some of these are in relief and others are painted in black or red ( Hose and McDou-

gal , 1912 ).

A popular dance in many Asian countries is the Bamboo Pole Dance , where two people sit and hold two bamboo poles at both ends. As the dancers' feet skip in and out of the space between the poles , the bamboos are brought together in time with the rhythm. Suspense is introduced because a dancer missing the beat will have his or her foot painfully caught between the thick bamboo poles.

Bamboo also has an important role in the literacy of Southeast Asia. In the Philippines , before paper arrived , bamboo was used to record the written word , using as a pen the point of a knife or other bit of iron , with which letters were engraved on the smooth side of the bamboo ( Colin , 1663 ).

Bamboo has inspired flowery descriptions by scientists. Wallace ( 1878 ) said that " A fine clump of large bamboos is perhaps the most graceful of all vegetable forms , resembling the light and airy plumes of the bird-of-paradise copied on a gigantic scale in living foliage". D'Orleans ( 1894 ) described his walk through a bamboo forest in what is today Vietnam : " Every kind of architecture is represented. Here are rounded pillars , others ornamented with arris ; there is the ogive , and further on the semi-circular , traves and architraves , low , damp , gloomy vaults and high , bold and graceful arches , full of daylight ; nothing could be stranger than this timber work , erected by nature , to support a canopy of verger , which shelters travellers from the rays of the glowing sun".

## 2.2 Bamboo : a resource of many uses

For some forest-dwelling people , the most important of all wild produce is bamboo , which is used to construct houses , household utensils , vessels , tools , weapons , baskets , water-pipes , rafts , musical instruments and various ornaments. In fact , Carey ( 1976 ) states that " the whole of Temiar ( a forest-dwelling group in Peninsular Malaysia ) material culture depends on the use of bamboo". Different varieties are used for different things , including poles for radio aerials , nets , fish traps , fish-screens , needles and pens , cooking containers , cooking sieves , hut posts , benches , chairs , and fences. Bamboo is an important trade item , and is often floated down rivers in rafts to sell in downstream market towns.

Bamboo was endowed by nature " with so many useful qualities , and delivered them into the hands of mankind so ready for immediate use , that a few sharp cuts sufficed to convert them into all kinds of various utensils" ( Jagor , 1875 ). The many uses of bamboo in China were enumerated as early as the Third Century in a treatise on bamboo ( Aero , 1980 ). A list published in Japan in 1903 included 1048 articles of practical use manufactured from bamboo ( Liese , 1985 ) , indicating the outstanding utility of this grass. The following list is presented to indicate the imagination and creativity of people striving to earn a living in a difficult environment :

### 2.2.1 Construction

In construction , bamboo provides pillars , floors , walls , doors , window frames , rafters , and room separators , ceilings , and roofs. In Borneo and the Naga Hills , large communal houses that may be 100 m long are built of bamboo. Bamboo is used to make guard houses in rice fields , road-side food shops , hothouses for growing mushrooms , smoke houses for drying tobacco or rubber , store houses for rice , and livestock sheds. Bamboo is used to make pegs which replace nails. Bamboo scaffolding is widely used in Asian cities , even on very tall buildings.

Many villagers use bamboo shingles , with the large stems split in half and laid them alternately with the convex and concave side upwards , with the edges overlapping ; in coastal areas , roofs often are made of thatch woven from nipa palm around long slivers of bamboo.

In Tonga , headrests are made of bamboo with hardwood supports.

Bamboo is used in China to make furniture , often without recourse to nails or glue , as the main framing members are notched and tapered to fit together like the pieces of a puzzle. The seats are

commonly made of slender bamboo slats.

Bamboo is used throughout rural Asia to build bridges of many types and sizes ; they can be as long as 25 m , often involving sophisticated technology as suspension bridges but also simple technology in the form of pontoon bridges ( Kurz , 1876 ).

With new technology , bamboo is replacing tropical woods in parquet flooring and iron rods in reinforced concrete.

### 2.2.2 Food and Cooking

The use of bamboo in food and cooking goes far back in history , and starts with making fire — bamboo is used to construct a fire-saw , using bamboo shaving for tinder.

As edible shoots , bamboo earns considerable income. Bamboo intensively managed to produce shoots will provide about 10 000 kg of shoots per hectare per year ( Sharma , 1982 ). Exports of bamboo shoots from Taiwan amount to US \$ 50 million per year ( Liese , 1985 ). However , in Chinese cooking , bamboo is strictly avoided for patients with ulcers.

Bamboo seeds are consumed as food in times of famine , with seeds of some species comparable to wheat in protein content and to rice in protein quality ( Sharma , 1982 ).

Dried mature leaves are used for deodorizing fish oils.

Tubers and rice are cooked in a length of bamboo which is then steamed or roasted over a fire ; this provides useful " trail food " , which can be taken on hunting trips or to distant rice fields to be eaten as a simple meal requiring no additional cooking.

Bamboo is used to construct frameworks for cooking pots over hearths in longhouses , and provides beakers for drinking water , beer , and various kinds of liquor.

### 2.2.3 Hunting and gathering

Bamboo is made into a wide variety of weapons. In Malaysia , negritos use bamboo to make blowpipes for hunting small animals such as monkeys and squirrels ( Carey , 1976 ) , while elsewhere in tropical Asia bamboo makes a quiver for darts for the blowpipes , and the darts themselves. In the Andaman Islands , bamboo reeds are used as fish arrows ( Radcliff-Brown , 1933 ). Bamboo is also widely used to make handles of spears and knives.

Bamboo helps to reach fruit which is out of reach , as poles for collecting coconuts , durians , or mangoes. In certain parts of Borneo , and no doubt elsewhere in tropical Asia , bamboo is used to make pegs which are driven into a tree to form a sort of ladder for climbing the tree to reach fruit or other resources ( Wallace , 1869 ).

In Sarawak , coastal villagers gather shell fish and worms by quivering a twig of bamboo down a hole and luring up the prey ( Harrison , 1970 ). In more inland areas , fishing is sometimes done with the use of fish poison known as tuba , which is pounded on a bamboo platform built over a pool.

Bamboo is widely used for making traps for animals or fish , ranging from sophisticated cage traps to simple dead-falls and pit traps with sharpened bamboo spears at the bottom of the trap.

Punan in Borneo make bamboo pipes with which to imitate the calls of deer and some birds ( Hose and McDougal , 1912 ) , thereby luring them close enough to be shot.

And after the food is collected , bamboo makes a carrying pole whose great strength , relative lightness , and springiness make it one of the most comfortable ways to transport loads over long distances.

### 2.2.4 Industry and agriculture

In India , bamboo provides almost the entire supply of long-fibre pulping material for the pulp , paper , board and newsprint industry ( Sharma , 1982 ). Seventy percent of the pulp used in making paper in India comes from bamboo , with an estimated annual production of about 250 000 t ( Soder-

strom and Calderon , 1979 ).

Bamboo is used a lever by which water is raised from wells , and to construct pipes to provide drinking water or irrigation water.

Some species of bamboo are used to make living fences , which are virtually impenetrable to livestock ( Kurz , 1876 ).

Bamboo is used as a raw material for making hats in various parts of Asia , especially Borneo ; these are becoming increasingly important in trade.

High-quality toothpicks and chopsticks are made from bamboo , and are finding an increasing market.

Bamboo is widely used to make the handles and framework for umbrellas.

Bamboo makes some of the most prized fishing rods.

Bamboo is being used as a filter in sewage treatment plants.

### 2.2.5 Miscellaneous

The tiny hairs in the wrapping of the new leaves are considered a slow and undetectable poison in Bali ( Covarrubias , 1937 ).

Liese ( 1985 ) reports that the rhizome of *D. hamiltoni* with slight dressing is an exact replica of a rhinoceros horn which fetches fabulous prices for medicinal uses ; only an expert can identify the imitation.

In Malaysia , Semelai villages have windmills made of bamboo to produce a loud and rather eerie sound , which can be heard many kilometres away. In a forested land with few pronounced geographical features , these windmills serve the important purpose of a sort of " homing beacon " ( Carrey , 1976 ).

Bamboo provides various medicines. For example , the sap that hardens between nodes is prescribed for asthma. Some species of bamboo in China are used to fight fevers , allay apprehension and restlessness , and detoxify. The Chinese also use it medicinally as a tonic for the stomach , as a cure against dysentery , and as a remedy for toothache.

Small wonder that bamboo is so highly valued throughout Asia. Indeed , the long and close association between people and bamboo in Asia led Porterfield ( 1933 ) to suggest that archaeologists would be justified in incorporating a definite Bamboo Age comparable with that of the Stone or Bronze in their historical chronologies for Southeast Asia.

And Ponder ( 1936 ) says , " In all the length and breadth of Java I doubt if there is a native house that has not its clump of bamboo growing in the garden wherefrom to cut for the thousand and one purposes for which it is used. Next to the rice on which they live there is no one thing that could be named which is so utterly indispensable to the people of Java as this native of their jungle , which they now cultivate so universally. " Bamboo is clearly deserving of much greater attention from those who are seeking to promote sustainable development in Asia.

## 3 BAMBOO AND BIODIVERSITY

But bamboo is important for far more than direct human uses , significant though these undoubtedly are. This section will outline the current knowledge on status and distribution of bamboo and indicate — at least in a preliminary way — the other species that are especially dependent on bamboo.

### 3.1 Taxonomy and distribution

Dransfield ( 1988 ) points out that a formal and overall classification of the woody bamboos has not yet been prepared and broadly accepted , but an estimate of about 60 ~ 75 genera and 1250 ~ 1500 species seems generally accepted. Sharma ( 1982 ) provided a list of 192 species of bamboo

from the Asia-Pacific region ,including both native and cultivated species. Of the estimated 180 species of bamboo found in Southeast Asia ,100 species are indigenous to the region and have relatively limited distributions ,about 30 are found only in cultivation and were probably brought in from other parts of Asia over the past 3000 years ,and about 125 species are growing wild in their natural habitat but have been brought into cultivation in other regions( Widjaja and Dransfield ,1989 ). Clearly , then , the distribution of bamboos has been greatly modified by human intervention.

Despite this taxonomic uncertainty and general paucity of research , some estimates for various parts of Asia are available. These are summarized in Table 1.

**Table 1** Species of bamboo in selected Asian countries

Country	Species of Bamboo	Area covered	Notes
Papua New Guinea	26		
Philippines	49		
Indonesia	+ 30		
Malaysia	28		19 endemic to Peninsula
Thailand	50	1 million hm <sup>2</sup>	
Burma	90	2.2 million hm <sup>2</sup>	
Bangladesh	33	.6 million hm <sup>2</sup>	
China	300	3.9 million hm <sup>2</sup>	
India	136	9.6 million hm <sup>2</sup>	produce 3.3 million tons

Sources : Dransfield ( 1989 ) , Sharma ( 1982 ) , Liese ( 1985 ).

The taxonomy of bamboo in Japan is puzzling. Sharma ( 1982 ) claimed that Japan has some 670 species of bamboo in 14 genera , covering about 148 000 hm<sup>2</sup> of which 144 000 hm<sup>2</sup> are private forests owned by farmers ; but Liese ( 1985 ) reported that Japan has 95 species covering about 125 000 has a producing about 280 000 t/a. We tend to believe the lower figure on number of species , but the message is clear that the temperate areas tend to support more species than the tropical countries.

### 3.2 Bamboo and wildlife

With primary productivity as high as that of many forests , bamboo provides support to many species of wildlife. Some of these , such as elephants( *Elephas maximus* ) , the wild cattle( *Bos gaurus* and *B. javanicus* ) , and various species of deer ( Cervidae ) and primates ( including macaques *Macaca* and leaf-monkeys *Presbytis* ) , pigs ( Suidae ) , rats and mice ( Muridae ) , porcupines ( Hystriidae ) , and squirrels ( Sciuridae ) are incidental feeders in southeast Asian bamboos ( Lekagul and McNeely , 1977 ). Schaller et al. ( 1985 ) report that in China sambar deer( *Cervus unicolor* ) , serow ( *Capricornis sumatraensis* ) , tufted deer( *Elaphodus cephalophus* ) and takin( *Budorcas taxicolor* ) all feed on bamboo. In Borneo and Sumatra , even orangutans go into bamboo to eat the young culms. In the Himalayas , Himalayan black bears feed on several small species of bamboo in high elevation forests close to the tree line. The impact of these species can be considerable. Rodents gnaw rhizomes and the base of culms and seeds ;and some species of squirrels eat the growing shoots. Pigs and porcupines also dig up many young plants to eat the rhizomes and young shoots. Elephants can cause considerable damage as they move through bamboo forests , seeming to take pleasure in twisting 10-cm-thick bamboo into complex knots ( Lekagul and McNeely , 1977 ).

Perhaps more interesting are the species of wildlife that are especially dependent on bamboo ,

and sometimes even totally dependent on it. The most famous of these is certainly the critically-endangered giant panda ( *Ailuropoda melanoleuca* ), whose distribution is determined by bamboo , though they prefer living in forests with a canopy coverage of 70% or more ( Schaller , et al. , 1985 ). Over 99% of the food of giant pandas consists of bamboo , with an average adult eating over 4500 kg/a , amounting to an estimated 466 000 shoots and stems , somewhat less than one percent of the available bamboo biomass per year ( Schaller , et al. , 1985 ). In essence , pandas have specialized on a plant resource available in virtually unlimited amounts at all seasons , though the nutritional quality of the bamboo is relatively low.

A closely-related species which is equally dependent on bamboo is the red panda ( *Ailurus fulgens* ), found from Nepal to Sichuan. The red panda has recently been added to Appendix 1 of the Convention on International Trade in Endangered Species of Flora and Fauna ( CITES ) , indicating that it too is endangered.

Many species of bats feed around bamboo clumps in various parts of Asia. These are primarily insectivorous bats , such as Kitti's hognosed bat ( *Craseonycteris thonglongyai* ), a member of a new family of bats discovered in Thailand in 1974. One genus of bats , *Tylonyctiris* , roosts inside of bamboo , usually *Gigantochloa scorteichinii* , gaining entrance through narrow vertical slits originally made by a beetle. These bats have distinctive foot-pads and thumb pads enabling them to grip the interior of the bamboo ( Lekagul and McNeely , 1977 ). They also have a remarkably flattened skull , which enables them to enter the small slits in the bamboo.

Species of rodent apparently confined to bamboo habitats include the marmoset rat ( *Hapalomys longicaudatus* ), which eats shoots , flowers , and fruits of bamboo and lives in the internodes of the bamboo which it enters through a round hole it has chewed in the internodes ; and the pencil-tailed tree mouse ( *Chiropodomys gliroides* ) ( Lekagul and McNeely , 1977 ). One family of rodents , the bamboo rats ( Rhizomyidae ) consisting of two genera and four species ranging from China south of the Yangtze to the eastern Himalayas and south to Sumatra , seem to be generally confined to the bamboo forests , feeding on bamboo roots and shoots , tubers , rhizomes , grass seeds and fallen fruits. They are burrowing animals , with some species growing as large as four kg ( Lekagul and McNeely , 1977 ).

With such high productivity , bamboo also supports many species of birds. In addition to the hundreds of species that may feed incidentally in bamboo forests , several species favour bamboo or are confined to this habitat. These include the mountain bamboo-partridge ( *Bambusicola fytchii* ), found from Burma to Vietnam , and the long-billed partridge ( *Rhizothera longirostris* ), which fills a similar niche in Borneo , Sumatra , southern Thailand , and Peninsular Malaysia. Species which feed on bamboo seeds include various species of finches and buntings , such as the yellow-billed grosbeak ( *Coccothraustes migratorius* ), the tawny-breasted parrot finch ( *Erythrura hyperythra* ), and the pin-tailed parrot finch ( *Erythrura prasina* ). Since many insects also find bamboo a productive habitat , many insectivorous birds favour these habitats as well. Species which are especially likely to be found in bamboo forests include Tickell's blue flycatcher ( *Cyornis tickelliae* ), hill-blue flycatcher ( *Cyornis banyumas* ), rufous-chested flycatcher ( *Ficedula dumetoria* ), mountain tailor bird ( *Orthotomus cuculatus* ), yellow-bellied warbler ( *Abroscopus superciliaris* ), rufous-faced warbler ( *Abroscopus*



*pus albogularis*), and golden-spectacled warbler (*Seicercus burkii*).

Several species of parrot-bills (*Paradoxornis*), various fulvettas (*Alcippe*), several babblers (*Stachyris*), the silver-breasted broadbill (*Serilophus lunatus*), and a suite of woodpeckers, including the maroon woodpecker (*Blythipicus rubiginosus*), the heart-spotted woodpecker (*Hemicircus canente*), the bamboo woodpecker (*Geninulus viridis*), the pale-headed woodpecker (*Geninulus grantia*), the laced woodpecker (*Picus bittatus*), the speckled piculet (*Picumnus innominatus*), and the white-browed piculet (*Sasia ochracea*) all favour bamboo habitats.

It is clear, therefore, that many species of wildlife depend on bamboo, either partially or entirely. Conserving bamboo will help conserve these species as well.

#### 4 CONSERVING BAMBOO

In some parts of Asia, most bamboo is extracted directly from forests, with almost 98 percent coming from natural stands; in other parts, such as Japan, Bali, and Java, most bamboo comes from cultivated sources. In any case, very little explicit attempt is made to conserve bamboo, and it appears that most conservation organizations see little need to give attention to bamboo when so many other species seem to deserve higher priority. However, given the cultural, social, economic, and biological importance of bamboo as outlined above, it may be timely to give careful consideration to the status and trends of bamboo, and to take corrective action if such is required.

##### 4.1 Conservation problems

**Synchronous flowering.** Bamboo is characterized by periodic synchronous flowering followed by death and subsequent regeneration. This synchrony may involve a few clumps, a patch, a whole mountainside or a drainage. These local synchronous flowerings may be complemented by much larger mass flowerings at cycles of 50 to over 120 years. However, in most localities, several species of bamboo occur, so the mass flowering of one species may be compensated by other species which do not flower, thereby keeping food supplies available for those who are dependent on the bamboo. In other situations, synchronous flowering and death of bamboo permits sudden widespread tree regeneration (Shidei, 1974) which may prevent the bamboo from regrowing.

Gregarious flowering has profound implications for the species which are dependent on bamboo. For example, gregarious flowering in China has been claimed to contribute to higher mortality rates of giant pandas by reducing their food supply in a geographically-constrained area from which emigration is impossible (Schaller et al, 1985); thus improved management of bamboo is an important part of conserving giant pandas.

The widespread death of bamboos in such conditions makes them vulnerable to fire damage, and can cause considerable human impacts as well. For example, Soderstrom and Calderon (1979) summarized the implications of the flowering and subsequent death of the bamboo *Melocanna bambusoides* around the Bay of Bengal, which flowers once every 30 to 35 years: "Death of the bamboo robs the population of its building material, and the excess of accumulation of bamboo fruits brings on a rapid increase in the rodent population. As the rodents increase, they devour whatever food is available, destroying grain fields and stored food. Such diseases as typhus, typhoid, and bubonic plague reach epidemic proportions with the rodent population explosion".

Further , the long growth periods of bamboo before flowering complicates conservation , as it is difficult to store their seeds. Scientists in India have induced one species of bamboo to flower in a test tube , but this was a major effort that has not been widely replicated ( Stevens , 1995 ).

**Impact of logging , deforestation , and shifting cultivation.** Bamboo usually survives logging , though its growth form is affected by removal of the forest canopy. Where significant deforestation has occurred , including deliberate destruction by warfare or fire , for example in Vietnam , bamboos have tended to increase and become established in pure stands that may persist for years ( Drew , 1974 ) , often replacing far more diverse assemblages of bamboo. This is perhaps an example of too much of a good thing , requiring intensive management to restore an appropriate balance between bamboo and other species of plants.

On the other hand , in some parts of Thailand , Burma , and Laos , shifting cultivation has resulted in expansion of the area of some species of bamboos , often at the expense of other types of vegetation that may contain more species ; again , the issue is one of balance.

**Over-harvesting and lack of regeneration.** In other cases , bamboo is threatened by lack of regeneration or over-harvesting from the wild. Sharma ( 1982 ) , for example , reports that bamboo forests in Thailand are threatened with lack of adequate regeneration due to removal of new shoots. *Gigantochloa* is the most widely used genus of bamboo in Southeast Asia and is under severe harvesting pressure , but it is also the one that is most important as a habitat for the species which seem to be confined to bamboo ( especially bats and rats ).

**Limited distribution.** Species of bamboo which are naturally rare , or which have limited distribution , may be especially vulnerable to habitat changes or over-harvesting. According to Dransfield ( 1989 ) *Arcemobambos setifera* has been reported from only three localities. *Bambusa montana* , *B. pauciflora* , and *B. klossii* have been reported from only a few localities. Of the seven species of bamboo which are known in China's Wolong Nature Reserve in Sichuan Province , four are rare or patchy in distribution ( Schaller , et al. , 1985 ). These species of very restricted distribution deserve special attention as significant alteration of their habitat might lead to extinction ; no doubt further study would reveal numerous other bamboos which fall into this category.

Schaller et al. , ( 1985 ) conclude that " The relationship between forests and bamboo is a dynamic one — a function of topography , the frequency and amount of natural disturbances to the vegetation , and the colonizing ability and flowering interval of the bamboo species , to mention just a few variables". A programme to conserve bamboo will require an understanding of the cyclic changes in the forest and bamboo community and better knowledge of the impacts of various management regimes.

## 4.2 Approaches to management

Management of bamboo in tropical Asia is under a wide range of regimes ( Sharma , 1982 ). In the Philippines , bamboo forests have been utilized without any regulatory techniques for their proper exploitation and management , while the Forest Department in Thailand is not involved in harvesting of bamboo. This lack of management attention has sometimes led to over-exploitation , especially from public forests. Incomplete knowledge on how to manage bamboo also can lead to over-exploitation. Especially on public lands , it is easy to fall into the temptation of felling all mature culms , but

this has the tremendous disadvantage of reducing the vitality of the clump , sometimes leading to the death of the clumps. One form of management practised in India is to harvest the bamboo well before it flowers , thus preventing the stock from flowering itself to death ( Kurz , 1876 ). The consensus is that selective felling is generally the best practice , using a system of annual coups worked in rotation.

In India , the sale of bamboo for pulp production is based on forest area , with a lump sum paid ; this sometimes includes a monopoly fee along with a royalty fee based on the number of bamboo. The purchaser may acquire the standing bamboo and harvest it himself , or he may leave the cutting to the owner who mostly does it more carefully. In the Philippines cutting from government-owned forests is controlled by village management plans and maybe carried out solely by residents of the particular area.

#### 4.3 An approach to conserving bamboo biodiversity

The preceding discussion suggests that a new effort to conserve bamboo is well justified by the combination of high economic , social , ecological , and cultural value ; inadequate knowledge of bamboo taxonomy , status , distribution , biology , and ecology ; and growing demand leading to increased pressure on the bamboo resources. Action will be required by at least the following groups.

**Scientists** need to expand their field collecting activities to support further work in taxonomy as a basis for investigating additional uses of bamboo ; and to assess the status and distribution of the various species. Ecological relationships with other species also need to be investigated , with a view to improving management.

It would be extremely useful to prepare an identification key for bamboo based on vegetative characters rather than flowers , since the latter emerge so infrequently. Scientists also need to conduct further research on the lifecycle of the various bamboos and the reasons for mass flowering , in hopes of developing the capacity to predict flowering and initiate appropriate management procedures.

**Conservation departments** should seek full information on the distribution of bamboo within protected areas and ensure that all wild species of bamboo are covered by the protected areas of the country. They need to be particularly aware of the successional stages in which bamboos occur , and instigate appropriate management regimes to ensure a distribution of appropriate successional stages within protected areas ; for example , species demanding early successional stages may disappear if the vegetation of a protected area is not appropriately managed.

Conservation departments also need to consider how to manage and promote natural regeneration following gregarious flowering and die-off. When bamboo occurs within the boundaries of protected areas , harvesting may be technically illegal , thus giving rise to tensions between the conservation and development interests. To earn support from local villagers , protected area managers should consider allowing at least some harvesting of bamboo under certain conditions , and might involve local people in management programmes.

**Botanic gardens** need to develop further collections and utilize these in research and public education , such as in the botanic gardens of Bogor ( Indonesia ) , Peradeniya ( Sri Lanka ) , and Singapore. More botanic gardens should raise different kinds of bamboo both to demonstrate the great di-

versity of these grasses and to build public awareness. Botanic gardens should also investigate ways of raising bamboo artificially , from seeds or by planting rhizomes , culm cuttings , and nursery-raised seedlings.

**Forest ministries** need to recognize the great value of bamboos , especially for local communities ; and ensure that research in forest management gives full consideration to bamboo. Research on optimal felling cycles and intensities for the different species should be conducted , perhaps beginning with quantitative assessments of bamboo resources ; this will involve determining growth rates and yields.

Forest ministries should investigate the possibility of planting bamboo under tree plantations as a means of increasing the diversity , value , and productivity of the plantations and providing more benefits to local people. This may require developing forestry regulations that include bamboo , perhaps building on precedents in India.

In Indonesia , the Ministry of Forestry has been cultivating bamboo in disturbed habitats to meet the demands of the paper industry and to prevent soil erosion ( Widjaja and Dransfield , 1989 ) ; this effort should be expanded and emulated elsewhere in the region.

Ministries of commerce and industry need to recognize the value of bamboos that are consumed locally as an important contributor to rural welfare. While such values seldom enter national income accounts , they may be substantial and contribute to a more complete picture of national well-being.

These ministries should also ensure that accurate statistics on local , national , and international trade involving bamboos are collected and publicized.

The use of various kinds of bamboo for construction should be further investigated and promoted , for example by providing appropriate incentives to the private sector.

**National governments** should give increased attention to the multiple values of bamboo , including biological , cultural , and developmental. For example , traditional uses of bamboos for musical instruments should be publicized , helping to preserve the traditional heritage of the people in the region and develop the industry on a commercial basis ; this would be especially relevant to Indonesia , Thailand , and the Philippines.

Further , it appears that many species of bamboo are especially likely to flower during years of drought ( Kurz , 1876 ). Some experts suggest that bamboo reserves might be seen as useful reservoirs for providing food during periods of famine , as the bamboo seeds produced following flowering are highly nutritious.

**The private sector** should seek more opportunities to tap into the growing market for bamboo products. Sophisticated technology has enabled bamboo to enter the highly competitive world market in the form of pulp for paper , parquet for floors , a new form of plywood made from bamboo , and veneers ; canned bamboo shoots are also finding a growing market internationally. This may require the provision of economic incentives to farmers ; for example , in Thailand , bamboo industries encourage farmers to establish bamboo plantations by offering incentives such as guaranteed prices , technical advice , and cheap seedlings and cuttings. Large bamboo plantations are now being established by private companies in southern Sumatra and east Java to fill the needs of bamboo-based industries including for bamboo shoots , chopsticks , toothpicks , and fancy handicrafts ( Widjaja and Dransfield ,

1989 ).

**Local people** should be given increased responsibility for managing their own bamboo resources. It is apparent that local people are capable of taking far greater responsibility for managing bamboo resources on public land. For example , Rutter ( 1929 ) reports that in North Borneo , the some Dyak villages claim reserves for tracts of country containing jungle products , or over clumps of wild bamboo over which individuals or groups of owners may assert a right. Penalties for infringement of rights are enforced by the village and are payable by money or chickens.

Particular attention should be given to the cultivated varieties of bamboo , especially those which support local village requirements. For example , environmentally safe and readily-available preservatives would greatly extend the useful life of bamboos used in construction of houses , bridges , and so forth.

In Nepal , some ethnic groups have ritual constraints against planting bamboo. While they greatly appreciate the benefits of bamboos , they believe that planting seedlings will result in the death of the planter ; however , planting vegetative material may not have such grave consequences ( Gilmour , pers. comm. ). Clearly , flexibility is the key in involving local people in bamboo management.

## 5 CONCLUSION

Widjaja and Dransfield ( 1989 ) consider the future prospects of bamboo to be bright , especially with increasing inputs from modern technology in bamboo production. Bamboo is of outstanding cultural , economic , and biological importance throughout Asia , but increasing human populations and expanding demands on resources require a more carefully considered approach to managing bamboo. Such an approach should include :

- ✦ scientific research to better understand the taxonomy , distribution , and biology of bamboo ;
- ✦ increasing incentives to farmers to grow bamboo and to use existing bamboo on a sustainable basis ;
- ✦ increased investment by the private sector ( supported by appropriate government incentives ) ;
- ✦ public education , including through botanic gardens ;
- ✦ and the establishment of protected areas devoted to the conservation of bamboo and the species dependent on it.

Such a programme will help ensure that bamboo will be able to make as great a contribution to the future of human welfare in Asia as it has to the history of humanity in this region.

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