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Bamboo resources, uses and trade: the future?

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Abstract—Bamboo products are well established in internal markets and on the world trade market. Accurate statistical information on this trade is difficult to find. International trade statistics suffer from outdated customs codes. However, the volume of world trade exceeds $2.5 billion and may reach $7 billion. Trade is generated from a narrow range of utilised species (perhaps 50 out of 1500 total bamboo species). Many under-utilised species are threatened by loss of forest habitat. The domesticated species could be more widely planted since bamboos are relatively tolerant of cold and of poor soils. Bamboo could be more widely used in construction: for example, bamboo can be used to reinforce cement, or to construct inexpensive houses and buildings that resist earthquakes and landslips. Also, bamboo can substitute for wood in many of wood's traditional uses — paper, fibreboard, glue-laminated furniture, panels and flooring. Edible bamboo shoots have developed rapidly in world markets. New uses for charcoal and medicine are developing. There will probably be insufficient wood to satisfy rapidly growing populations with higher living standards in (particularly) India and China. Bamboo can and probably will expand in quantity and quality of uses.

Key words: Bamboo; resources; trade; uses.

INTRODUCTION

The purpose of this article is to review the current situation with regard to bamboo resources and trade, and to make predictions as to its likely development. Since the subject of this seminar is resources and trade the paper will emphasise products that might enter into international trade. However, the distinction will not be applied rigidly, since to do so might lead to anomalies — discussing international trade between two small countries while ignoring internal consumption patterns in giant countries like China and India.

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THE CURRENT SITUATION

Bamboo trade

Bamboo products are well established in many countries as products of first choice for containers, mats, housing, etc. Bamboo products are also well established on the world market. It is difficult to estimate the exact size of domestic and international markets. Domestic markets are not quantified exactly. International markets suffer from the difficulty that the custom codes have not been revised to reflect changes in the pattern of trade. INBAR with it's member countries has been leading the effort to obtain this revision in the World Custom's Organisation. Even with revision, difficulties will remain in identifying composite products (bamboo and wood for example). Although we know that the current volume of world trade is $2.5 billion we believe that the total may exceed $5 billion. China generates a very significant fraction of the exports. The EC and USA take 80% of imports. Therefore, bamboo is a very significant component in world trade, having export sales as great as bananas and only slightly less than cotton. Tropical timber by comparison has a trade of $14 billion.

For countries where we can gain some estimate of the size of the domestic market in relation to the export market we believe it to be at least five times as great.

Bamboo resources

Bamboo occurs as an understorey component in many forest types in the tropics and warm temperate latitudes [1]. It occurs naturally as pure stands often as an altitudinal belt on mountains. It also occurs as nearly pure stands in certain semi-natural situations. These may have arisen as a result of large-scale disturbance in the forest cover. Forest recovering from natural or man-made disturbance may trend towards a distinct bamboo-dominated sub-climax for reasons that are not always clear [2, 3]. Man can easily assist this process and produce 'Bamboo Seas' with relative ease, since bamboo is generally easy to regenerate artificially. Bamboo will grow in isolated clumps on parts of the farm with, unlike isolated trees, no loss in wood quality. It takes only three or four years for bamboo to start producing yield and thereafter, every year, it produces the same amount until overtaken, after 50 or more years, by gregarious flowering.

There are, however, over 1500 species of bamboo and less than 50 species are routinely cultivated. The remaining species rely on their natural forest habitat for survival and that habitat, as the joint WCMC-INBAR project showed, is disappearing. Greater effort is needed both for *in-situ* and *ex-situ* conservation of threatened species.

For the cultivated species, there has been a pattern of expanding plantations and more clumps on farms in parallel with expanding demand. Bamboo as a crop rather uniquely dovetails with the short planning horizons of the human species.

THE FUTURE

Bamboo resources

Only a narrow range of the available species has currently been domesticated. For industrial usage domestication has clearly favoured the tall growing, large-culmed species. A distinct set of small to very small species have been selected for the important but entirely separate landscape market. However, there are many large growing species that are not routinely used. It is the impression of this author (supported by the results from Ref. [4]), that, while bamboo species do differ between themselves in key wood characteristics, they do not differ as much as different species of trees in this regard. However, differences in wood characteristics for certain uses [5], splitting characteristics and other handling criteria have sometimes been mentioned as reasons for not preferring certain species. Nevertheless, it seems probable that as knowledge of bamboo uses expands more species will be domesticated.

People with a peripheral knowledge of bamboo routinely make the mistake of thinking of it as a tropical plant. In fact, there are bamboo species growing well into the cool temperate zones of Asia and high up in mountains where the climate is distinctly cold [6]. The INBAR 'species-to-site matching' project identified over 25 species that could tolerate winter minima less than -20°C and three that could tolerate -29°C [7]. It is fair to say that bamboo will grow into the high fifties latitude where oceanic influences moderate winter temperatures (e.g. Western Canada, Western Europe). The EC-funded project 'Bamboos for Europe' established trial plantings of 17 species at sites across Europe (Table 1), including a site on the north German plain. Yields ranged from 7 t DM/ha/per year (DM is dry material) at the northerly sites to 15 t DM/ha/per year at warmer, wetter sites. With this level of productivity, bamboo is a serious contender for biomass production. For Europe it has been placed in the top five contenders because it's productivity is good; it can yield continually, it stays green all year (which is a very useful characteristic from a landscape perspective); it has a higher water-use efficiency than other contenders and it has desirable physical qualities for biomass energy conversion [8]. Europe and America have much surplus agricultural land which could easily be used. Thus, the prospects for a large increase in both the scope and scale of bamboo resources are good.

Bamboo is also a very tolerant plant of poor soils. This is important in a world where there are large areas of degraded soils. A key INBAR project near Allahabad in India showed that bamboo species could be used to rehabilitate soils that were heavily degraded as a result of brick-field mining. Bamboo established and grew on the residual soil and within a few years provided the shelter and soil-improvement that enabled other cash-generating crops to be grown. Bamboo has also been shown to be useful in artificial wetlands for effluent treatment [9].

Table 1.
Bamboo species grown in N. Europe

Phyllostachys vivax
P. aureosulcata
P. propinqua
Fargesia mureliae
F. nitida (two varieties)
P. humilis
P. nigra
P. praecox
P. viridoglaucescens
Phyllostachys var 'Zwijnenburg'
Pseudosasa japonica
Sasa disticha (syn *Pleioblastus distichus*)
S. keguma
S. palmata
S. pumila
Semiarundinaria kagamia

USES

Bamboo houses

Around the world many people live in houses and use buildings that are vulnerable to earthquake, landslip and other natural disasters. Yet with good design, many of these events are survivable. Good design does not necessarily mean great expense. Two of the Millenium Development goals address this concern directly: improvement in the conditions of life for slum dwellers and provision of education and health care (for which buildings will be needed).

On March 2, 1987, a series of earthquakes measuring up to 6.5 on the Richter Scale shook the Rangitaiki Plains, parts of which subsided by up to 2.05 metres. Rifts opened in the ground, buildings and a dam were damaged, as were roads and railway lines, and a railway locomotive was toppled on its side by the shake. A crack, 7 kilometres long, opened in the Rangitaiki Plains near Edgecumbe. 50% of the houses in Edgecumbe were damaged. It was estimated that the damage caused by the earthquake cost $150 million. One person died from a heart attack, possibly caused by the shock of the earthquake, but there were no other deaths. This low casualty rate was because all the buildings, most of which were wood-framed, were built with earthquake resistance in mind. The performance of wood-frame construction was surveyed [10] in a number of recent earthquakes: Alaska, 1964; San Fernando, California, 1971; Edgecombe, New Zealand, 1987; Saguenay, Quebec, 1988; Loma Prieta, California, 1989; Northridge, California, 1994; Kobe, Japan, 1995. They concluded that wood-frame construction can withstand the shaking from large earthquakes without serious distress and often without damage provided that appropriate anti-seismic procedures are followed by designers, builders and owners.

Bamboo houses built using a pole structure have many of the components of wood-framed houses and offer many of the same disaster-resistance benefits. They are light, yet strong. INBAR has done much to advance the design of such houses [11]. However, as yet they lack clear building codes to guide architects and builders. They also need further design work on joint strength; rigidity and cross-bracing if they are to offer exactly same benefits as wood-frame houses.

It has been known for a fairly long time that split bamboo can be used with confidence as reinforcing for concrete [12, 13]. This design principle can be used in combination with bamboo pole construction or other forms of construction to produce wall panels for houses; reinforced floors and ceilings. The principle is already well-known in the Latin American bahareque style of building.

Difficulties with jointing bamboo poles and the weakness of bamboo poles in tension (hence in long-span roof members) has led to the development of glue-laminated 'bamboo lumber' from bamboo matboard. The design concepts follow those used for plywood beams and trusses [14, 16]. This 'bamboo lumber' is being used to fabricate roof trusses for a school building in China.

One very great advantage of building with bamboo is that much of the raw material for the building can be accessed close to the building site, which limits transport requirements and makes building in poorly accessible places easier.

NEW TRADABLE USES FOR BAMBOO

Bamboo can substitute directly for wood in many of its uses. Bamboo articles are particularly hard and durable. Bamboo, therefore, tends to substitute for hardwood products. As world population and standards of living rise, the supply of hardwood products comes under greater pressure. At the same time there is a growing concern amongst environmentally-aware consumers that using hardwood products might exacerbate deforestation — particularly in the tropics. Thus, we must expect that a current tendency to wood substitution will continue.

The need to substitute wood pulp with bamboo pulp either in entirety or mixture may also be driven by demand and supply constraints. New, large consumers of these products are entering the world stage. Two of these consumers (China and India), accounting for 40% of the world's population, have very limited forest resources to draw upon. For example annual consumption of wood in China is forecast to rise to some 233 million m^3. This would be commensurate with a shortfall in supply of 60 to 70 million m^3. In 2000 China imported some 3.4 million tons of wood pulp and 3.7 million tons of waste paper. Just one year later these imports had jumped to 4.9 and 6.4 million tons, respectively. The 2001 figures reveal that 38% of China's total paper pulp requirements are being met from imports. The cost in that year alone was over $2.7 billion. China is also a major producer, consumer and importer of finished paper products. In 2001, total production and consumption of paper and cardboard ranked second in the world

surpassed only by the USA. Development of a bamboo-based industry has been strongly suggested.

One of the critical factors enabling an explosion of new uses for bamboo has been the relatively development of glue-laminated technology. This has enabled the development of parquet flooring (currently a $50 million export industry from China); panels; mouldings [17] and many containers and daily-use items. Bamboo parquet flooring compares very well with good hardwood flooring [18].

In 2002 INBAR sponsored a design competition for modular or 'pack-flat' furniture using glue-laminated bamboo boards [19]. Bamboo boards have a very hard surface and are very suitable for heavy wear furniture such as desks and tables. This type of furniture is already in production.

Bamboo matboard has been made for many years [20]. It consists of woven mats of split bamboo pressed together to form a product that resembles plywood but thickness for thickness, is stronger. Bamboo matboard is being used in China instead of tropical plywood for concrete formwork. It is used as the floor of the tray of light trucks. It can be used structurally in light houses. Now, it is being corrugated to substitute for galvanised iron in roofing panels [21]. International trade in plywood is large and bamboo matboard could substitute for some of it.

Paper has been made from bamboo for millennia. India has a moderate size industry in kraft-type pulp from bamboo. However recently China has begun to fabricate laser- and photo-copy paper from bamboo. INBAR reported on tests of this paper in comparison with wood-based paper in its News Magazine [22]. Bamboo pulps tend to have relatively long fibres accompanied by substantial amounts of fines. Bamboo fibres differ from wood fibres, leading to a fast beating time for the pulp but a higher beating energy. The presence of the fines probably explained the different drainage resistance of bamboo paper that was found. Tear strength and burst index were similar to hardwood pulps. Tensile strength and stiffness tended to be lower than softwood pulps but could be improved by removing the fines. The bamboo paper was not as bright as some wood based papers and this is thought to be due to coarser fibres and light absorption by fines. The coarser fibres gave a rougher surface. All in all, the testing laboratory concluded that the bamboo paper was not as good as spruce/birch paper. However, to the untrained eye the differences are minimal and INBAR, which has used this paper in its office for three years, finds them of no practical significance. With further refinement of manufacture such bamboo papers could also become a major traded item.

The international market for bamboo shoots has grown to over $150 million per year from China alone. Approximately half goes to Japan. Bamboo shoots are exported canned, packed in plastic and dried. There is interest from restaurants in America and Europe. To further stimulate interest INBAR collaborated in the production of a 'fusion' cookbook combining Western cuisine with the use of bamboo shoots. INBAR has also sponsored research into the use of bamboo flour in new products [23].

There is a small established market for medicinal products made from bamboo. There has, as yet, been little systematic development of this market.

Bamboo charcoal is valued as an air purifier and for a range of other anti-pollution uses. Activated bamboo charcoal is now traded internationally. Activated charcoal from bamboo has a higher surface area than that from wood and, therefore, is more effective weight for weight [24].

CONCLUSIONS

Resources of the domesticated bamboos can be expanded speedily and easily to match demand. There is little likelihood therefore of a great imbalance between demand and supply. The non-domesticated species face a more uncertain future.

Uses and trade in bamboo have grown rapidly in recent years. Bamboo can substitute for wood in many of it's uses. It is to be expected that as demand for wood-like products increases and environmental concerns about deforestation remain strong, bamboo will increasingly substitute for wood. Likely areas of further penetration include flooring, panels, paper and bamboo matboard for plywood.

Bamboo is also likely to make inroads into house and building construction particularly in the developing world as new designs show that it can be used to construct culturally acceptable yet strong and safe buildings.

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