Bamboo Products and their Environmental Impacts: Revisited

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Introduction

In 2005 Dovetail investigated environmental attributes of bamboo[1], a material that had several years earlier been firmly embraced by the green movement in the absence of any serious attempt to determine what impacts actually result from its production and use. At that time, our investigation revealed many environmental concerns associated with growing, harvesting, and converting bamboo to useful products. Problems reported throughout bamboo-producing regions included clearing of natural forests for establishment of bamboo plantations; creation of monoculture plantations; loss of biodiversity; substantial use of fertilizers and pesticides despite claims that bamboo crops required neither of these treatments; and unsustainable harvesting of natural stands of bamboo. We concluded our earlier report with the observation that the unquestioned green status accorded bamboo products needed serious re-evaluation and that, at a minimum, third-party certification should be required before awarding any kind of green status to bamboo products.

In this report we revisit bamboo products and environmental impacts associated with their production and use. We also provide updated information regarding availability of certified bamboo products and their performance. This report focuses on bamboo production in China, which has by far the largest and fastest growing bamboo industry.

Brief Background

While discussion in this report centers on the relatively recent rise in bamboo's global use, it is important to realize that bamboo has long been used for a myriad of purposes, including construction of dwellings and other structures. In fact, bamboo culture has been described as an essential part of human history and civilization, especially in Asia (Lobovikov et al. 2007). There is a long history of bamboo use in South America as well.

Today, similar to the last 5,000 years, bamboo is used as a primary building material in many parts of the world (Figure 1). Currently, over 1 billion people are estimated to be living in traditional bamboo houses (Lobovikov et al. 2007). Lightweight and high strength bamboo stalks 4-5 inches in diameter provide structural support, and can also be lashed together to form panels used for roofing, flooring, exterior walls and partitions, doors, and window frames. Bamboo strips can be woven to form mats and window coverings. In addition, bamboo is used for scaffolding in construction projects – often to great heights. While bamboo continues to be used in these traditional ways, it has also become an important raw material for production of modern building products.

Figure 1
Bamboo House in the Central Philippines

[1] Bowyer et al. (2005). (http://www.dovetailinc.org/files/DovetailBamboo0305.pdf)

Bamboo is also used as a raw material in furniture production and papermaking, as a fuel (in the form of charcoal, oil, or as a gas produced through pyrolysis), as a fiber for making cloth, and for making a range of products from chopsticks and tableware, to packaging materials, to medicines and other health care products (Xiang 2010).

Another primary use of bamboo is food, with shoots consumed both fresh and in a variety of processed forms. Mertens et al. (2008) report that some 200 species of bamboo provide shoots for human consumption. Bamboo shoots are now popular throughout Asia and much of the world.

China is reported to have both the largest and fastest growing bamboo sector, involving more than ten million bamboo farmers, providing 35 million jobs (Buckingham et al. 2011; Yiping and Henley 2010; Hogarth and Belcher 2013; Xiang 2010), and generating a market value of over $10.5 billion (Buckingham and Belcher 2013). China is also dominant in exports of various bamboo products for the global market. Given its dominance in bamboo production and export, the remainder of this report is focused on China. Other countries with significant bamboo resources and bamboo exports include Vietnam, Indonesia, Thailand, and the Philippines. India has a large Bamboo resource, estimated at about 9 million hectares (or about 30 percent of global total), that as of 2008 only contributed about 4 percent of the global market (Sharma, 2008).

Building a Green Mythology for Bamboo Flooring

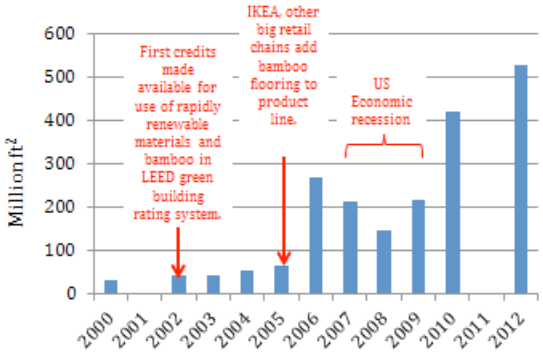
Although produced in limited volume in China beginning around 1990, more than a decade would pass before bamboo flooring began to make inroads into world floor covering markets. As described recently in BuildDirect.com (2012):

> *"Bamboo first made its appearance as a floor covering on the international market in the early 1990s to a lukewarm reception. The product was undeniably beautiful, but without the perspective of education, it was a hard sell. People in the United States were familiar only with common local uses, like old-fashioned fishing poles from the slender, flexible varieties of bamboo native to North America, and from imported items like back scratchers and chopsticks. Changing the perception of bamboo as a viable flooring option with a hardness rating comparable to most hardwoods and a sustainability factor that makes it a green choice was a slow process . . ."*

A significant turning point occurred in November 2002 with the USGBC designation of rapidly renewable materials, including bamboo, as *environmentally preferable materials* in its Leadership in Energy and Environmental Design (LEED) v. 2.1 Standard. Within three years bamboo flooring production had increased significantly in China, foreshadowing a much larger production expansion. The "green" bamboo genie was out of the bottle (Figure 2).

About two thirds of bamboo flooring in 2005 went to the export market, with the vast majority to the United States and the European Union (van der Lugt and Lobovikov 2008). In the U.S., the number of suppliers of bamboo flooring rose from less than 10 in the late 1990s to about 200 by 2005, with imports in 2005 approximating 45 million ft.[2] (Malin and Boehland 2006). Similar growth in bamboo flooring consumption occurred in the EU, although total sales amounted to only 1/5th to 1/6th that of the U.S.

Figure 2
China Bamboo Flooring Production, 2000-2012



Source: For the period 2002-2007: U.S. International Trade Commission (2008); for 2008-2009: Petry et al. (2010); for 2000 and 2010: Hansen et al. (2013); and for 2012: globalwood.org. (2013).

Anointment of bamboo as a green material was based on broad and unquestioned acceptance of the idea that rapidly renewable materials (i.e. those that renew in 10 years or less) are somehow inherently environmentally superior to those that renew in 11 years or more. It was (and remains) an idea that made little sense, but one that was nonetheless embraced by LEED, as well as a number of other green building programs patterned after the LEED program. This took the form of green points for use of non-certified bamboo along with FSC certified wood in construction. Even governments got into the act. For instance, the Governmental Construction Organization of the Netherlands (*Rijks Gebouwen Dienst*) also accepts non-certified bamboo as a green material (van der Lugt and Lobovikov 2008).

In 2005, as now, the websites and promotional literature of bamboo promoters were rife with glowing claims about the environmental attributes of bamboo. Currently, environmental claims are a bit more restrained than in 2005, but misinformation continues to be disseminated via a number of sources. For example, a 2008 article in Scientific American (Earth Talk 2008) that continues to be cited, states:

> *"Bamboo's environmental benefits arise largely out of its ability to grow quickly – in some cases three to four feet per day – without the need for fertilizers, pesticides, or much water . . .Bamboo is so fast growing that it can yield 20x more timber than trees on the same area."*

These same claims can currently be found on the life.gaiam website (Gaiam 2011), on HubPages (Spence 2013), and on bambooki.com (2011). As discussed below, these characterizations of the environmental impacts of bamboo are completely false.

Another site (Morris 2012) references the "vast supply" of bamboo (isustainableearth.com 2012), stating ". . . there are reportedly more than 1.6 million square miles of bamboo growing in China alone, with most of these native forests owned and managed by the Chinese government." With regard to this latter statement, China's bamboo resource in 2010 was reported by the UN Food and Agriculture Organization (FAO) to be a little over 5.71 million hectares (14.1 million acres) (Buckingham et al. 2013), an area that is equivalent to slightly over 22,000 square miles (1/72nd of 1.6 million square miles), the vast majority of which is plantations that are managed by farmers. Rapid renewability is a recurring theme in these and other websites.

Meanwhile, the U.S. Green Building Council (USGBC) has at long last discontinued the availability of credits for use of rapidly renewable materials in its 2014 LEED v.4 Standard. Under the new standard, bamboo products originating from farmed plantations must comply with the Sustainable Agriculture Standard of the Sustainable Agriculture Network, and if

otherwise obtained must have been legally harvested, in order to qualify for green credits. It is a long overdue, but important step forward. Under these new guidelines promotion of bamboo products, such as bamboo flooring, as environmentally preferable materials will be much more difficult than previously.

Although LEED has made changes, the rapidly renewable mindset is firmly entrenched in many green building programs across the United States. Among those programs that continue to endorse bamboo and other rapidly renewable materials as environmentally superior, absent any requirement for additional information, are Atlanta Earthcraft Homes, Build-it-Green, California Green Point Rated, Built Green Colorado, King County (Seattle) Green Building, Western North Carolina Green Building, Minnesota Green Star, Scottsdale Green Home, Wisconsin Ecofriendly Home, and many others. Moreover, even though USGBC has now abandoned the rapidly renewable concept, a recent decision on the part of the federal Government Services Agency (GSA) guarantees a continued legacy. That decision endorsed the use of the Green Globes and LEED green building rating systems in federally funded building projects, but with respect to LEED, the GSA specifically endorsed use of only LEED 2009 and not the latest version of this standard.

China's Bamboo Resources

Occurrence

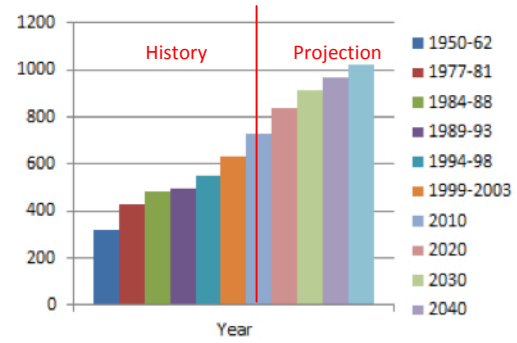
China's State Forestry Administration Seventh National Forest Resource Inventory Report in 2009 indicated a total bamboo forest area of 5.38 million hectares (13.3 million acres) with the majority of this area in plantations. This was a significant increase in comparison to the 4.2 million hectares recorded in a 1998 forest inventory (Petry and Lei 2009; Mertens et al. 2008). Natural bamboo also occurs in smaller quantity within mixed forest stands across 18 of China's 22 provinces, with more than half of this volume in just three provinces – Fujan, Jiangxi, and Zhejiang (Song et al. 2011). The primary bamboo producing areas within China are indicated in Figure 3.

Figure 3
Provinces of China and Principal Bamboo Forest and Plantation Areas
(Fujan, Jiangxi, and Zhejiang in the upper right of the larger circle)

Expansion

As a consequence of actions to expand the resource base, the occurrence of bamboo is reported to have increased steadily over the past two decades, both in surface area (31.6%) and in density of stands (40.8%) (Mertens et al. 2008). The current area represents 1.5 times the estimated area in the 1950s, and has increased by about 0.1 million ha annually since that decade (Song et al. 2011). Continued expansion is attributed to smallholders and managers of government forest farms who preferentially plant bamboo on their designated forest land over slower growing and less profitable timber species (Booth 2013; Hogarth and Belcher 2013). Chen et al. (2009) documented expansion of bamboo resources by focusing on carbon stocks (Figure 4). Their findings show steady growth from 1950 to 2010, and the likelihood of continued expansion through at least 2040.

Figure 4
Carbon Stocks in Bamboo Stands in China (Tg)



Source: Chen et al. (2009)

Despite the diversity of bamboo species, just one species – the Moso bamboo (*Phyllostachys pubescens*) – is dominant in cultivated plantations and enrichment plantings within natural stands. Yiping and Henley (2010) report that the area of land devoted to Moso bamboo increased from 1.5 million hectares in 1957 to 5 million hectares (12.4 million acres) in 2007 in China through natural expansion and plantation establishment. As a result, moso bamboo currently accounts for more than 80% of China's bamboo area.

China's Recent Bamboo History

The extent of bamboo in China has grown substantially since about 1970 in response to a combination of administrative orders and applied afforestation[2] subsidies directly aimed at increasing bamboo resources through planting. With an objective of improving income potential for rural areas, early measures included organization of farmers through local governments to reforest degraded forest land and reestablish bamboo resources. More recently, rapid expansion of bamboo plantations occurred following a series of policy reforms in the mid-1980s that impacted land tenure and forest use rights, markets, and commercialization. A key development was implementation of the Farmer Households Production Responsibility System in 1983. Farmers responded quickly to the new marketing system - a combination of contract and free-market selling - by increasing bamboo production at an average annual rate of over 5% for the period 1983-1988 (Maogong et al. 1998).

Although bamboo production stagnated and fell between 1988 and 1990 after government sales quotas were cancelled, rising demand from a growing processing sector quickly led to revitalization

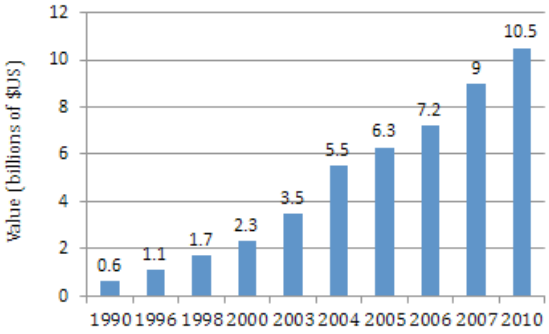
[2] The terms "forest" and "afforestation" are commonly used in Asia and by FAO when referring to bamboo, even though bamboo plants are grasses and not trees.

of markets (Maogong 1998). An important result was that smallholder investment in and management of plantations was enabled. Subsequently, the central government offered financial incentives to local people to plant more bamboo in the area and increase the density (i.e. number of stems per hectare) of bamboo stands (Gallagher 2011).

Another, seemingly unrelated, government action had a profound impact on consumption of bamboo within China. In 1998, China introduced a widespread logging ban following a summer of unusually heavy rainfall and devastating flooding events. As a result, the nation's forest products manufacturers quickly shifted to imported wood as a source of raw materials. At the same time, many who had relied on local wood for a variety of purposes rapidly switched to bamboo, a change that dramatically increased domestic bamboo consumption (Gallagher 2011, Song 2011). However, even as this change was taking place, market oriented reforms in combination with increased emphasis on research and development were driving rapid development of commercial bamboo processing. This has had the effect, over time, of reducing traditional, small-scale domestic use of bamboo (Mertens et al. 2008).

The overall consequence of these initiatives and policy changes was increased production of bamboo products, ranging from bamboo shoots to raw bamboo and various manufactured products, which combined to markedly increase the value of China's bamboo industry (Lu 2001; Yiping and Henley 2010) (Figure 5). Export of bamboo products increased as well. Research also provided a foundation for establishment of new bamboo-based industries including engineered panels and other construction products. More than 20 different types of bamboo panels are reportedly manufactured in Asia, including particleboard and medium density fiberboard. Among the engineered products is bamboo flooring, a product that is sometimes made of combinations of wood and bamboo.

Figure 5
Value of China's Bamboo Industry



Source: 1990-2007: Yiping and Henley (2010);
2010: Hogarth and Belcher (2013)

Environmental Impacts of Bamboo Industry Expansion

From a social perspective, expansion of bamboo resources and industrial production has been quite successful. Numerous studies have documented expansion of household incomes and poverty reduction through increased bamboo production (Perez et al. 2003; Marsh and Smith 2006; Booth 2013; Hogarth and Belcher 2013). Planting of bamboo on steep slopes previously terraced for agricultural production has helped to stabilize these slopes and reduced runoff and erosion in many areas (Maogong 1998; Moberg and Persson 2011). These benefits have been aided by development of standards for reforestation (Panda Standard Association 2012).

The bamboo phenomenon, however, has been accompanied by substantial environmental costs. Outlined below are observations of a number of investigators and research teams.

Impacts on Biodiversity

- Gallagher (2011): "Encouragement from the authorities, coupled with the obvious financial gains from planting and harvesting bamboo, has led to widespread over-harvesting and intensive monoculture plantations in many parts of southwest China in recent years. Unbeknownst to many locals, this has resulted in serious negative effects on local ecosystems, worrying environmental and scientific observers."
- Li Yanxia, Sichuan program officer for the International Network for Bamboo and Rattan (INBAR), as quoted by Gallagher (2011): "During the past 15-20 years, a vast area of natural bamboo forests in many counties in the province has been turned into monoculture forests . . . There is an urgent need to demonstrate long-term technical and policy strategies to halt and restore the degraded biodiversity and the natural productivity of the damaged forests. The trends of monoculture forests lead to biodiversity loss and ecosystem service decrease. Local communities believe that monocultures can bring more income. To change this strong belief is the main challenge."
- Yiping and Henley (2010): "As the bamboo sector has grown over the last few decades, management practices in bamboo forests have changed. Traditionally, mixed forests containing both bamboo and other plant species have been sources of bamboo timber and fibre for centuries, but extraction generally occurred at a low intensity, and natural generation of the bamboo in the forests provided ample supply."
- Yiping and Henley (2010): "The principal means of increasing yields is to increase the density of bamboo culms per unit of land, effectively creating monocultures."
- Yiping and Henley (2010): "While undoubtedly successful in generating rural incomes for farmers and taking pressure off scarce forestry resources, the intensification of economic activity in bamboo forests has had negative effects on the biodiversity in these forests in south and south-western China. Intensive farming practices, encouraged by policies and forestry extension services have led to reduction in species and ecosystem diversity in bamboo forests. Although intensive management practices have led to higher yields of bamboo in the short-run, in the long-run these forest ecosystems are experiencing a reduction in resilience to external threats including pests and disease and weather events, and a reduced capacity to provide important ecosystem services including erosion control and nutrient cycling. And importantly, they are also leading to lower productivity of bamboo forests in the long run."
- Buckingham et al. (2011): "Chinese bamboo forestry is dominated by one monopodial species, *Phyllostachys heterocycla* var. *Pubescens* known as Moso. . . Currently the big policy challenges relate to the regeneration of intensive monocultures, promoting mixed forestry, combating soil erosion and assuring adequate fertilizer applications."
- Buckingham et al. (2011): "Bamboo is an invasive."
- Song et al. (2011): "Moso bamboo has been expanding rapidly into other types of forest and gradually replacing previous pioneer tree species at higher altitudes and latitudes in recent decades. . . This expansion of Moso bamboo has greatly decreased the biodiversity and threatened the existence of other species in some areas, especially for some rare and endangered species, and this is an increasing concern. "

- Yiping and Henley (2010): "While raising production in the short-term, these [current] management practices negatively affect species diversity and compromise the long-term stand quality, resilience, and productivity of monoculture bamboo forests. . . A number of studies have demonstrated the loss of biodiversity associated with management techniques that promote monocultures." Examples were provided of declines in grass and shrub diversity from 58 species to 31 species over an 11-year period following introduction of new bamboo management techniques, leading to monoculture, of 45 and 90% declines in soil fungi and bacteria diversity, respectively, and of avian diversity loss associated with intensive culture of bamboo. With respect to the latter, Yiping and Henley cited one study that found "monoculture bamboo forests in Hunan and Sichuan with much lower avian diversity than nearby mixed forests. In Hunan, 15 species of birds were observed compared to 35 species in nearby mixed forests. In Sichuan, 12 species were observed compared to 34 species in nearby mixed forests."
- Yiping and Henley (2010): "Decline of biodiversity in bamboo forests is thought to negatively affect both site quality and resilience of stands to disease, pests, and adverse weather events. For example, although the bamboo rhizome system is a powerful soil binder, other vegetation found in bamboo forests plays an important role in protecting soil from erosion. Removal of species often results in increased wind and water erosion resulting in nutrient depletion. Vegetation, along with many bacteria, fungi, and insect species, act to maintain soil quality by nutrient cycling."
- Yiping and Henley (2010): "Reduced resilience together with lowered site quality ultimately negatively affects long-term productivity of bamboo forests." One recent study cited found a 25% decline in productivity in an 11-year study of monoculture forests in Fujian and Zhejiang. Another study found that bamboo produced in mixed broad-leafed forests was higher in terms of quality (diameter and weight) and biomass than bamboo produced in monoculture.

Impacts on Forests

- Song et al. (2011): "It is worthwhile to note that some farmers have begun returning farmland to bamboo forest in the pursuit of higher profits, which may constitute a potential threat to China's food security and therefore merits concern. Perhaps more importantly, in mountainous areas, some other types of forest have been clearcut to plant bamboo for current economic benefit without considering the site condition and future market changes. Moreover, most bamboo forests are located in the source regions of China's main rivers and water systems, where inappropriate forest type changes and management often leads not only to biodiversity loss, but also to heavy soil erosion and subsequently excess transport of N and P into surface waters via surface runoff, thereby exacerbating surface water pollution and eutrophication of downstream."
- Song et al. (2011): "Intensive management of the Moso bamboo forest can simplify the structure of the forest and decrease the species richness and biological diversity of the tree, shrub, and herb layers, and can decrease soil microbial activity and biodiversity . . . Moreover, under intensive management, the natural soil fertility and site quality have gradually declined in some Moso bamboo forests, accompanied by damage to the soil's physical structure and consequently to a decrease in its water-retention capacity."
- Li Yanxia, Sichuan program officer for the International Network for Bamboo and Rattan (INBAR), as quoted by Gallagher (2011): "The rapid growth in demand for bamboo resources over the last two decades has caused excessive exploitation of forest resources in

the province. This has resulted in serious disturbance and destruction of the biodiversity of ecosystems in natural bamboo forests."

- Hyde et al. (2003): "On the demand side, bamboo and timber compete in many of the same markets – panels, flooring, and plywood. On the supply side, they compete for similar farm resources because China's national forests have been substantially depleted of their accessible bamboo and commercial timber."
- Mertens et al. (2008): "In Anji county, the land cover transition probability matrix shows the major role played by forest in providing new areas for bamboo extension: about 23% and 30% of the forests shifted to bamboo plantation during the two periods of observation [1984-1995; 1995-1999]."
- (Mertens et al. 2008): "They [bamboos] appear to be more profitable than timber trees (such as Chinese fir or Pinus plantations) and benefit from an expanding national and international demand, both as a substitute for wood fibre and for some superior goods like bamboo shoots and bamboo flooring." These are several factors that explain ongoing replacement of tree plantations (in some cases degraded) with bamboo.

Use of Fertilizer, Herbicides, and Pesticides and Intensive Management

- Yiping and Henley (2010): "The principal means of increasing yields is to increase the density of bamboo culms per unit of land, effectively creating monocultures . . . This is achieved primarily through active clearance of other vegetative species, including trees, shrubs and undergrowth. The aim of this is to provide greater space, nutrients and water for the bamboo. This is commonly done by performing two brush cuttings per year to clear the forest floor of saplings, seedlings, shrubs and herbage. In addition, topsoil tillage is performed every one to two years and chemical fertilizers and pesticides are applied in varying quantities. Through the application of these techniques, annual yields of bamboo have been raised from 3.5 tonnes per hectare to 7-10 tonnes per hectare. Under optimized conditions, this can even reach up to 35 tonnes per hectare."
- Song et al. (2011): "Although bamboo forests provide considerable ecological and socioeconomic benefits, there are potential problems associated with their cultivation, including a decline in biodiversity, soil and water loss, decreased soil fertility, and water pollution due to intensive management using inorganic fertilizers and pesticides."
- Song et al. (2011): "Intensive management of the bamboo forest offers higher productivity than extensive management of the bamboo forest or naturally growing bamboo . . . Thus, increasing numbers of bamboo forests are being turned from natural conditions or extensive management towards intensive management. "
- Maoyi and Xiaosheng (2004): "As a fast-growing plant, bamboo consumes substantial quantities of nutrients. It is estimated that, on average, farmers annually apply 200kg (440 pounds) of fertilizer (mainly nitrogen) per hectare to bamboo plantations."
- WenYan and NaiXun (2013): "About 150 kg N per hectare as effective component of chemical fertilizer is applied in May or June for sympodial bamboos and in July or August for monopodial bamboos during the first 1-2 years after planting. 350 kg N per hectare are needed in the third year, plus 15-30 tons of organic fertilizer, applied in winter." [Moso bamboo is a monopodial species]

Water Use

There is no evidence that water requirements for bamboo plantation maintenance are low. In fact, most references suggest that bamboo does best with an abundance of rainfall. A sampling of findings are reproduced below:

- JiangJua and QingPing (2012): "Monopodial bamboos prefer sites with a warm, moist climate and annual precipitation over 1,200 mm. In China, for instance, their central distribution area is located between the Yangtze River and the north of the Nanling mountains. North of the Yangtse they extend up to the Yellow River basin, where the main climate factors affecting monopodial bamboo's growth are drought during the growing season and severe cold in winter. Monopodial bamboos should be grown in sunny sites with high rainfall in spring and summer and easy access to irrigation."
- Xiao and Yang (2013). "The medium or large-scale bamboo plantation may be established in any bamboo growing region of the world. Additionally tropical, subtropical and temperate regions that presently do not have natural bamboos are also suitable. There are many species suitable for different climatic conditions and some are very frost-hardy. However bamboos are not suitable for very dry areas unless irrigation is provided."
- Siddiqui (1994). "Bamboo is not a suitable commercial species for areas where sufficient water is usually not available."

Yield of Bamboo vs. Tree Species

When rates of hardwood production in natural stands within temperate forests, managed to 80 to 100 year harvest cycles, are compared with "timber" production in intensively-managed bamboo plantations in subtropical regions, with 4-6 year harvest cycles, bamboo can be shown to have yields seven to ten times those of wood (Table 1). Yield differences can be as much as twenty times greater using record plantation yields as a basis for comparison. This latter statistic also more or less matches claims made on previously cited web sites.[3] However, when wood yields from intensively managed plantations of eucalyptus (a hardwood that is also used in making flooring) are compared with yields from intensively managed plantations of bamboo, the yields are similar or often higher for eucalyptus. Yiping et al. (2012) found comparable yields in a study that employed modeling to compare growth rates of bamboo and eucalyptus. Clearly, statements that "Bamboo is so fast growing that it can yield 20x more timber than trees growing on the same area" are true only if limiting the comparison to very dissimilar resources and using exceptional growth rates for bamboo.

Although differences in yield between subtropical bamboo and temperate hardwood species are impressive, it is worth considering these differences in the context of impacts linked to intensive plantation management. Periodic harvesting of temperate forests obviously impacts the environment. But when the full range of impacts linked to intensive culture is taken into account, the notion that fast growth and rapid renewability should automatically qualify bamboo or any other material as environmentally preferable to periodic harvesting in natural forests appears to have no scientific basis.

[3] While yield can differ by a factor of 20 when comparing lowest yields for temperate hardwood forests of species commonly used in manufacturing flooring with record reported yields from intensively managed bamboo plantations in sub-tropical regions, average differences are more on the order of 3-5x. Comparisons of only merchantable bole volume of hardwoods to bamboo yields result in yield differences of 6-10x.

Table 1
Yield of Plantation and Naturally Occurring Bamboo vs. Plantation and Forest-Grown Wood Species

Species	Moso bamboo (China)[4]	Eucalyptus (China and elsewhere)[5]	Moso bamboo (China)[6]	Hard Maple (US)[7]	Red Oak (US)[8]
Growing environment	Intensively managed plantation	Intensively managed plantation	Natural forests	Natural managed forest	Natural managed forest
Harvest cycle (yr.)	3-6 yr.	6-8 yr.	8 yr.	80-100 yr.	80-100 yr.
Harvest method	Partial harvest to clearcutting	Clearcutting	Selection harvesting	Selection harvest	Selection harvest to patch clearcutting
Avg. above ground stem growth over harvest cycle – ovendry mass/green volume (mt/ha/yr)	7.0-10.0 (up to 35.0 in optimal conditions)	7.9 - 23.0 (up to 35.0 reported)	6.6 - 8.8	2.0-3.0*	2.0 -3.0*
Annual yield in comparison to US hard maple (x)	3.5 – 5.0	4.0 - 11.5	3.3 – 4.4	--	--
Regeneration method following harvest	Sprouting	Replanting	Sprouting	Sprouting, natural regeneration	Sprouting, natural regeneration, replanting
Fertilizer applied?	Yes	Yes	No	No	No
Herbicides applied?	Usually No (hand tending for weed control)	Yes	No	No	Yes
Pesticides applied?	Yes	Yes	No	No	No
Number of fertilizer applications over an 80-year period	160	10-28	0	0	0
Number of herbicide applications over an 80-year period	0	20-28	0	0	1-2
Number of pesticide applications over an 80-year period	40-80	20-28	0	0	0
Number of harvest cycles over an 80-year period	14-20	14	10	1-2	1-2

* Figures are typical yields of above-ground biomass in an 80-year rotation. Yields are about one-half this if considering only the main bole or sawlog portion. Good data on usable stem yields of bamboo unavailable.

[4] Yiping and Henley (2010)
[5] Bowyer (1999)
[6] Scurlock et al. (1999)
[7] Ontario Ministry of Natural Resources (1998)/Goodman et al. (1990)
[8] Ontario Ministry of Natural Resources (1998)/Sander (1990)

Bamboo Certification

At the time of our earlier report, environmentally certified bamboo was available only through Smith & Fong. Today, bamboo that has been certified by the Forest Stewardship Council (FSC) is also available.

Regarding FSC certification, Buckingham et al. (2011) have questioned whether certification by this body is well conceived, or even helpful. Criticizing the costs of certification, Buckingham and colleagues suggested that this creates market barriers for smallholders – the majority of bamboo growers. They also questioned certification of intensively managed, large-scale, monoculture plantations. Similarly, Henley et al. (2014) questioned the benefits of certification, pointing out that there are several challenges in the subsequent chain of custody for the villages. They also noted that it was unlikely that a premium for certified bamboo could be gained given present consumer demand. At least one alternative to certification is now available in the form of the previously mentioned Sustainable Agriculture Standard.

The Bottom Line

Bamboo is a marvelous resource that provides a myriad of benefits for billions of people. Development of bamboo resources is economically assisting impoverished people while at the same time stabilizing erodible slopes and flood-prone watersheds. The ability to substantially accentuate rapid growth through intensive management for commercialization purposes magnifies its many benefits. The benefits, however, come at a high environmental cost. Degradation of natural forests, tremendous biodiversity loss, widespread use of fertilizers and pesticides, loss of resilience in bamboo resources, and increased social and environmental risks linked to large-scale monoculture agriculture are among the costs.

The rapid renewal capacity of bamboo is a reality. But reality is replaced by fantasy when rapid growth is equated to environmental superiority without serious consideration of practices employed to achieve rapid growth. Fantasy becomes even more fantastic when completely unfounded claims are accepted without question.

As we concluded in 2005, bamboo products should never be designated as environmentally preferable materials without at the very least requiring careful consideration of environmental impacts throughout the entire supply chain. It is time for all players in the green building arena to replace rapid renewability credits with a bit of common sense.

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