Teak Plantations: Economic Bonanza or Environmental Disaster?

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Teak (Tectona grandis L.f.) is a high-value tropical hardwood with unique wood properties. Teak timber is diminishing in its native range and most teak now comes from intensively managed plantations outside the native range. With increasing demand for high-quality teak wood, plantation area is only expected to increase. There are currently many criticisms and uncertainties expressed in the literature and in public forums regarding the establishment of new teak plantations. The literature indicates issues limiting the potential for teak including wood quality, silvicultural methods, pest problems, and environmental considerations. A field survey of teak plantations along the Pacific Coast of Mexico revealed that silvicultural methods are well known and effective, and most environmental negatives can be mitigated through landscape-level decisionmaking. This article provides information that can assist institutions and investors in deciding whether to consider plantations of high-quality, short-rotation teak in suitable climatic regions.

Keywords: teak (Tectona grandis L.f.), plantations, tropical hardwood, wood quality, Mexico

Teak (Tectona grandis L.f.) is a valuable tropical hardwood that has been grown in plantations for hundreds of years (Pérez 2005). It is valued for its unique wood characteristics, being incredibly durable, decay resistant, and remarkably beautiful (Nair 2007). These wood properties enable teak to be used for a variety of wood products, and demand for this species is increasing (Krishnapillay 2000). Teak plantations are being established throughout Latin America (Pérez 2005). There are about 35,000 ha of teak in Mexico, representing roughly 10% of the total area of teak in Central and South America. With these new plantations come new issues and uncertainties. We reviewed the worldwide teak literature and conducted a field survey of teak plantations in Nayarit, Mexico, to assess what issues face teak plantations in the future.

Wood Properties of Teak

Teak is one of the world’s premier hardwood timbers, well known for its color, fine grain, and durability (Keogh 1996, Pandey and Brown 2000). Its heartwood combines several qualities such as termite and decay resistance, lightness and strength, drying without warping and splitting, easy workability, and attractive appearance (Nair 2007). The appearance of fresh cut teak wood is dark golden yellow, turning dark brown or almost black with age and feels waxy (Kribs 1968). When exposed to the elements, teak weather to a silvery gray (Kribs 1968). Teak wood contains natural oil silicates that preserve the wood in saltwater environments and prevent corrosion when placed next to metal (Anonymous 1994). No satisfactory substitute has been found for teak in this application (Anonymous 1994). Teak wood is moderately hard and heavy with a specific gravity of 0.55–0.70 (oven-dry weight), with a weight of 35–45 lb/ft³ (Kribs 1968). Teak wood is used for hundreds of purposes including ship building (decking, planking, frames, and keels), the construction of buildings and bridges, railway carriages and sleepers, luxury and exterior furniture, cabinets, flooring, decorative veneer, and wood carving (Kribs 1968, Evans 1992). Teak’s position among timbers has been likened to that of gold among metals and diamonds among precious stones (Nair 2007).

Wood Quality in Plantation Grown Teak

One important issue that is debated in the teak literature is the question of how...
Economic Bonanza?

Teak is a premium hardwood species with a high demand, attracting much investor attention around the globe (Pérez 2008). Depending on the objectives and timeline of a given plantation, the profit and rate of return can be much more appealing than other investment alternatives (Pérez 2005). Some plantation investors advertise high return rates with dividends beginning in short time frames (Ball et al. 2000). In Costa Rica, excellent crops and economic returns can be obtained from teak plantations with results of 8.6 m$^3$/ha per year for 25-year rotations (Bermejo et al. 2004). Teak grows to timber quality of plantation grown teak compares with that of native grown teak. Teak has different wood characteristics when grown in different areas (Zobel et al. 1987, Oteng-Amoako 2004). The general consensus is that wood from teak plantations is inferior to that of native forests (Krishnapillay et al. 2004). Ladrach (2009) has argued that plantation grown teak has similar wood density to native teak, but density is not a singular measure of wood quality. The driver in the debate over wood quality is the amount of heartwood produced by plantation grown teak (Figure 1). The proportion of heartwood is an important factor, in that during its formation certain chemical processes take place, which improve durability and change the color of the wood (Kokutse et al. 2004).

These characteristics add considerable value to teak timber (Viquez and Pérez 2005), and most teak logs are priced based on their heartwood percentage and appearance. Wood quality is an important determinant of market price. Grading rules for native teak obtained in Asia are currently limiting the selling options of several forest companies in Central and South America (Pérez 2005). Plantation grown teak from Central and South America often do not meet minimum log dimensions and wood quality because of defects (Pérez 2005). Grading rules have made it challenging for plantation grown teak to compete in the international market that includes natural forest grown teak.

Teak Silviculture

General ecological requirements of teak are well known. Teak typically grows best in warm tropical climates in which there is a 3- to 5-month dry season (dry month defined as 50 mm or less of precipitation during the dry season) with annual precipitation levels of about 1,500–2,000 mm and a mean annual temperature of 22–27°C (Keogh 1996). Suitable soil types are sandy and slightly clay, fertile, deep, and well drained, with a neutral or slightly acid pH (De Camino et al. 2002). The range of elevations in which teak occurs is highly variable and dependent on specific site characteristics, but plantations are rarely planted higher than 1,000 m above sea level (Pandey and Brown 2000). Although general ecological requirements of teak are known, the relationship between ecological condition or silvicultural treatment and wood quality are not as well known. Detailed discussions and additional literature on this point can be found in a study by Pérez (2005) and Ladrach (2009). In general, the older and slower-growing teak trees have a higher proportion of heartwood. This may vary from 55% heartwood in young trees (less than 30 years old) and 80–90% in older trees (Pérez 2005). Teak growing on dry sites can have much higher percent heartwood at a young age. However, wood density may not vary all that much as a function of age and growth rate (Ladrach 2009). It is only through deductive reasoning, e.g., higher planting density equals slower growth equals higher percent heartwood, that we can link silvicultural practices and wood quality because of the lack of specific studies. Coupling the lack of a singular measure of wood quality in teak grading rules and little knowledge about how silviculture affects wood quality leaves this an important unanswered issue. As can be seen in the teak plantations of Nayarit, Mexico, all of the aforementioned factors are highly important when selecting an appropriate site for producing a quality teak crop (Figure 2). Planting teak on unsuitable sites has resulted in poor seedling establishment and/or complete planting failure.

Table 1 summarizes the silvicultural plan for teak in Nayarit, Mexico. Initial planting is 3 × 3 m spacing; with approximately 1,100 trees/ha. The first thinning selects for tree form, light availability, and competitive advantage between residual trees. Commercial thinning is conducted around age 2–6 years and the two lowest-quality trees are removed out of a grid of four, thus creating a consistent mosaic across the stand. Crown pruning is conducted throughout the rotation period. Because teak forms epicormic branches, removal of coppice shoots is conducted throughout the rotation period to ensure a clear and uniform stem. Rotation ages are usually 20–30 years.

Figure 1. Variation in sapwood and heartwood proportions of plantation teak grown at different rotation ages and climates. (A) Slow-growing teak from Ghana (note high proportion of heartwood; Photo courtesy of Dr. S. Bredau). (B) Fast-growing teak from Nayarit, Mexico (note small percentage of heartwood). (C) Sawn lumber from heartwood (Africa). (D) Sawn timber with heartwood and sapwood (Nayarit, Mexico).
size on good soils in Central America, with resulting economic benefits (Bermejo et al. 2004). Successful teak plantations are attracting investors with projected returns as high as 24% and dividends beginning as early as year 5. Strong demand for teak poles is reported in many countries growing teak (e.g., Ghana and Mexico) and sales of such thinning materials can significantly increase the returns on the initial investment (Ball et al. 2000). Fast growth rates are also attractive to investors with some plantations in Nayarit, Mexico, producing a mean annual increment (MAI) of 8–10 m³/ha per year.

Growth rates around the world widely range from location to location. Teak plantations are capable of achieving a MAI of 4–18 m³/ha per year and higher on 40- to 80-year rotations (Evans 1992). Teak plantations in Central America, e.g., grow much faster and produce greater timber volumes compared with other countries such as India and Indonesia (Pérez 2005).

With these incentives come many risks, such as detrimental effects from catastrophic events, market competition, available capital, and current political stability of a given country. Problems also exist with some plantation promoters misleading uninformed investors with overestimated growth and yield models. Because teak has gained a worldwide reputation because of the attractiveness and durability of its wood, teak plantations can be expected to increase in other suitable countries where the same potential can be achieved (Pérez and Kanninen 2005). Teak timber from native forests is becoming progressively restricted, and plantations are expected to become the primary supplier (Krishnapillay 2000).

Although teak plantations are seen as an attractive investment, there is a great deal of uncertainty in market prices. In February 2002, the International Tropical Timber Organization reported an average price of US$700/m³ for teak roundwood, ranging from US$2,000/m³ for teak logs of first- and second-grade quality to US$600/m³ for fourth-grade teak logs (Pérez 2005). Plantation grown logs from Costa Rica would be rated as fourth-grade teak logs with a minimum diameter requirement of 29–48 cm (Pérez 2005). Market prices for teak timber can vary from US$400 to 2,500/m³, depending on the grading rate assigned to the product (Pérez 2005). With no uniform grading and pricing system for teak wood in Central America and other tropical countries, buyers and sellers mutually determine the price after reaching a consensus on the basis of log size, wood quality, and volume under negotiation (Pérez 2005). Forest companies in Costa Rica export logs to foreign markets with prices ranging from US$70 to over 500/m³ (Pérez 2005). With such uncertainty in price it is easy to see why some investors are hesitant to invest in this natural resource. Lack of knowledge about the relationship between silvicultural treatment and wood quality means it is difficult to predict the final value of a teak crop.

Keogh (2008) proposes an international pricing mechanism that would provide solutions to the widespread uncertainty and confusion surrounding plantation teak log prices. He argues that grading rules need to be developed to create standards for a pricing mechanism. Such a pricing mechanism would bring transparency to teak pricing and benefit the entire teak sector.

Environmental Disaster?

Biodiversity

The topic of plantations and biodiversity was recently reviewed by Stephens and Wagner (2007). Although it is clear that
monocultures of trees have lower biodiversity than natural forests, the appropriateness of this comparison is questionable (Stephens and Wagner 2007). A more appropriate comparison is the biodiversity of land that is converted to plantations or represents an alternate use. With most monocultures comprised of a single exotic species, there is by design little room for competing vegetation. The characteristics of a fast-growing highly competitive tree that make it a desirable choice for plantations are the same characteristics that reduce biodiversity of other species. Plantation size in Mexico rarely exceeds 100 ha and they are distributed across the landscape. Landscape biodiversity may still remain high, depending on what plant associations occur outside the teak plantations.

Teak plantations, although considered detrimental to wildlife by some, perform an important role in providing habitat connectivity and protection at a landscape level (Bonnington et al. 2007). Large mammals in Tanzania use teak plantations as corridors between fragmented islands of habitat but do not occupy them as they do natural forest types (Bonnington et al. 2007). Wildlife corridors are protected within and in close proximity to teak plantations in Nayarit, Mexico. These corridors allow movement between isolated habitat areas for animals such as howler monkeys (Alouatta palliata G.) and military macaws (Ara militaris L.). Teak plantations when planned as part of a larger landscape can provide benefits to wildlife.

**Plantation for Restoration**

Teak plantations are being established mostly on abandoned farmland such as banana and mango plantations in Central America and Mexico and on degraded land planned for restoration or reforestation (Pandey and Brown 2000). Teak plantations provide an economically appealing alternative use of abandoned farmlands, areas dominated by invasive species, and areas needing protective forest cover. One example of the establishment of teak for restoration purposes is in the Panama Canal Watershed. Craven et al. (2008) examined the feasibility of using tree species such as teak to shade out the invasive canal grass (Saccarum spontaneum L.) within the Panama Canal Watershed. They propose using commercial timber species to control the invasive grasslands in a restoration effort. They found that teak has the ability to rapidly establish in such areas with the appropriate amount of herbicide applications and mechanical cleanings needed to combat the invasive canal grass. Once established, the teak shades out the invasive grass, and once the teak has fully colonized the site and excluded the grass, it may be possible to reestablish other native species.

Teak plantations are used in other restoration efforts, such as soil conservation practices. Boley et al. (2009) examine the effect of teak and mixed native plantations on soil chemistry of abandoned pasture land in Costa Rica. They found that teak plantations may help increase soil fertility of abandoned pasturelands. They suggest that teak landowners only clear understory vegetation when teak trees have become well established to promote nutrient retention and soil protection. This would seem like an attractive option for a landowner whose objectives are to both produce timber and rehabilitate the land in the long run.

**Risk of Pests**

As with all monoculture plantations, planting teak carries certain risks. A newly established teak plantation can be devastated by a pest that is native to the area where teak is introduced and makes a host shift to teak or a pest that is introduced into Mexico. Four insect pests are of recognized importance to teak plantations in their native habitat. They are the defoliator Hyblaea puera, the skeletonizer Eutectona machaeralis, the bee hole borer Xyleutes ceramicus, and the sap sucker Maconellicoccus hirsutus (Nair 2007, González-Gaona et al. 2008). They are all distributed throughout the Asia–Pacific region, but H. puera exists in all tropical regions and has recently (1995 in Costa Rica and 1996 in Brazil) attacked teak plantations in Latin America (Nair 2007). Other insects introduced from outside Mexico that are also pests include the pink hibiscus mealybug M. hirsutus, which has recently attacked teak plantations in Nayarit, Mexico, triggering both a monitoring and a biological control program (González-Gaona et al. 2008).

**Conclusions**

Environmental degradation caused by teak plantations is usually the result of poor management actions. Poorly established plantations can cause environmental problems. Well-established, environmentally sound plantations can have positive environmental effects. Properly established, well-managed plantations do not necessarily degrade the landscape-level environment. Appropriate site and provenance selection and management strategies can mitigate environmental concerns.

A number of factors limit potential productivity of teak plantations. Teak wood is a product in high demand. That demand can be met with timber produced from intensively managed plantations outside its native range. An increase in teak production is evident in areas such as Nayarit, Mexico. Addressing factors outlined in this article may encourage the expansion of plantations to suitable climatic regions capable of producing high-quality, short-rotation teak. Whether teak plantations are an economic bonanza or environmental disaster is a function of whether they are planned and managed by professional foresters with a sound understanding of silviculture, environmen-
tal protection, and world markets for this elite timber species.

Literature Cited


