HARDWOOD SAWING TECHNOLOGY IN FIVE TROPICAL COUNTRIES

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ABSTRACT

In this study, hardwood sawing technology was identified in five tropical countries: Ghana, Brazil, Venezuela, Indonesia, and Malaysia. The density of the wood and presence of silica make it a challenge to saw many tropical hardwoods. The bandsaw is the most commonly used machine and is employed in many sizes and configurations. Sawblade parameters and operating procedures vary according to the nature of the species being sawn and are influenced as much by local custom as technical knowledge of the process. The most commonly reported problems include poor saw maintenance, lack of trained personnel, obsolete equipment, and inadequate sawtooth geometry and wear resistance.

The purpose of this study was to identify hardwood sawing technology and the problems experienced by sawmills in tropical countries. We studied five countries that we could obtain the most information for: Ghana, Brazil, Venezuela, Indonesia, and Malaysia. We believe these countries represent the range of conditions in Africa, Asia, and Latin America. Sources of information included: available literature; visiting scientists at the USDA Forest Service, Forest Products Laboratory; other research institutions; sawblade manufacturers; the Food and Agriculture Organization of the United Nations; the International Union of Forestry Research Organizations; and several universities.

It is not our intention to discuss tropical deforestation (17). We believe that the present and future value of the forest is enhanced by knowing how to efficiently process its wood. Particular attention should be given to species that are abundant but regarded as difficult to process as a result of silica, high density, or other characteristics.

SAWNWOOD PRODUCTION

The total hardwood sawnwood production for the five countries (,Ghana, Brazil, Venezuela, Indonesia, Malaysia) is about 21 percent of the world's total. From 1980 to 1991, output increased in each country except Venezuela. Brazil's sawnwood output was more than 60 percent of the total for South America in 1991 and 7 percent of the world's total.

SAWNWOOD EXPORTS

Of the five countries, Malaysia exports the largest quantity of sawnwood, about 30 percent of total world exports and more than 50 percent of its production. Ghana exported about 40 percent of its sawnwood production in 1991, which was about 14 percent of the total for Africa and 1 percent of the world's total. Brazil's exports were less than 5 percent of its sawnwood production in 1991, but nearly 3 percent of the world's total exports **(Table 1).**

SAWING RECOVERY

The sawing yields reported for the subject countries are the percentage of log volume converted into lumber, whereas in North America recoveries are usually reported as board feet per cubic foot of log. The two cannot be compared without knowing the following:

- Are results based on green thickness or finished thickness?
- What are the typical log diameters?
- What is the number of board feet per cubic foot?

A very good recovery rate in southern pine is 8.2 board feet per cubic foot for dry finished lumber. This has been recalculated as a volume yield of 58 percent (Phil Steele, Professor, Mississippi State Univ., Starksville, Miss.). The typical range is likely 50 to 60 percent for this industry for diameters up to 24 inches. For recovery based on rough green dimensions, 10 board feet per cubic foot has been reported, which translates into

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approximately 70 percent yield. For U.S. hardwoods, recovery is likely in the range of 45 to 55 percent. Hardwoods are sawn for grade, and the term "board foot" is interpreted differently for hardwoods than for softwoods.

Tropical countries are more likely to have larger diameter logs than are available in the United States. The lumber is cut to nonstandard thicknesses, without reporting if recovery is based on green or finished dimensions. For these reasons, meaningful comparisons are difficult.

GHANA

FOREST RESOURCES

African forest resources are rich only in the southwest area where 70 percent of the surface is covered with forest, and half of this is dense forest (11). Large areas of forest are cleared each year for agricultural use (12). As a result of agriculture, overlogging, and deforestation, several areas will either be totally deforested in 10 years or all known stocks of commercial species will be exhausted. Eight-five percent of production is used as firewood; only a small part is used in the form of structural wood.

Ghana has $0.08 \times 10^6 km^2$ of forest with 680 tree species, of which 66 have major economic value (76.3 % of standing volume). Another 60 species are potentially marketable (18.3 % of standing volume). However, only about 40 species are considered commercial, for which there are both domestic and export markets. A second group of 20 species is considered marginally commercial. Two abundant species are wawa *(Triplochiton scleroxylon), 15* percent of standing volume, and esa *(Celtis* spp.), 12 percent of standing volume (11).

Characteristics of some Ghanan species that can cause rapid dulling of cutting tools in machining include the following (basic specific gravity based on ovendry weight and green volume):

- High density: Kaku *(Lophira alata), 0.90* basic specific gravity
- Silica: Bediwunua/Eyere *(Canarium schweinfurthii), 0.40* basic specific gravity;
- Calcium carbonate deposits: odoum *(Chlorophora excelsa* and C. *regia), 0.55* basic specific gravity (3).

SAWMILLING

In Africa, more than 90 percent of the sawing machines are bandsaws (27). Wheel diameter ranges from 1.10 to 1.80 m. Stellite is the basic tooth material; feed speed varies from approximately 5 m/min. (small bandsaw) to 35 m/min. for an average cutting depth of 0.40 m. Green lumber thicknesses are theoretically 21,27,34,42, and 54 mm, but may vary 20 percent because of poor equipment maintenance. Lumber is not planed, and average yield is 40 percent, increasing to 50 percent in the best case (from log to boule, not square edged).

In Ghana, harvesting and cutting of timber are highly mechanized with rules and regulations (26). Every tree 60 to 62 cm in diameter or larger is numbered, and every felled tree is recorded. The largest logs are processed in mills closest to the forest, if possible, because transportation is inefficient.

The Timber Export Development Board of Ghana(6) states that from 1990 to 1992, average annual lumber production was 576,000 m^3/year. This is greater than reported in **Table 1;** no explanation is available for this difference. Lumber uses include joinery, mouldings, construction, paneling, profile boards, flooring, furniture, boxes/crates, cabinets, pallets, sleepers, windows, doors, window frames, and boat building. Plantation stock is used for poles. The average local market share of lumber is 340,000 m^3/year, and the average export share is

TABLE 1. — Estimates of hardwood sawnwood production and exports (7).

Location	Production 1980	Production 1991	Exports 1980	Exports 1991
	(× 10^3 m^3)			
Ghana	225	400	69	161
Brazil	7,738	9,256	662	429
Venezuela	349	235	--	--
Indonesia	4,800	9,008	1,203	756
Malaysia	6,284	8,860	3,212	4,934
Africa	5,621	6,112	1,104	869
Asia	43,357	53,316	6,628	7,064
World	115,790	130,825	13,190	14,931

TABLE 2. — Common types of sawblade geometry.

	Wheel diameter	Profile	Type	Saw: Thickness	Saw: Width	Saw: Pitch	Saw: Gullet depth	Saw: Side clearance	Angle: Hook	Angle: Clearance	Angle: Sharpness
	(m)			(mm)					(degrees)		
Ghana	1.8	Shape S	Stellite	1.47;1.65	254	55	22	0.61	25 to 30	12 to 16	44
Brazil											
Sample A	1.25	Gum	Swaged, alternate teeth	1.25	120	45	11	0.8	10	20	60
Sample B	1.25	Gum	Swaged, alternate teeth	1.25	114	45	15	0.8	17	23	50
Venezuela											
High density	1.4	Gum	Stellite	1.30	150	45	13	0.6	22	12	56
Malaysia											
Headrig	1.5	Gum	Stellite, alternate teeth	1.47;1.65	206	45	12.7	0.6	25	16 to 18	47 to 49
Small resaw	0.9 to 1.1	Gum	Stellite	1.06;1.24	102	32	11	0.5	25	16 to 20	45 to 49

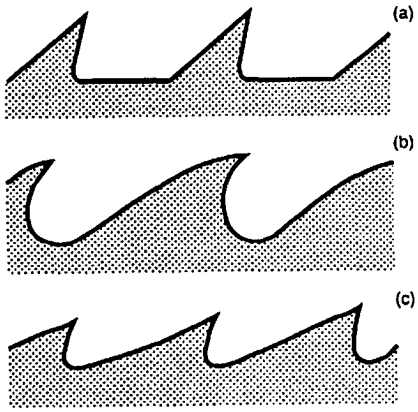

Figure 1.— Tooth profiles: (a) flat-bottom gullet or "gum" shape; (b) shape S, preferred for wide bandsaw blades; (c) shape N or tooth of the "wolf."

236,000 m^3/year. This volume is greater than reported in **Table 1;** no explanation is available for this difference. The dimensions range from 25 to 100 mm in thickness, 150 mm or more in width, and 1.8 m or more in length. Lumber is occasionally planed upon request.

The current bandsaw parameters used in Ghana for cutting tropical hardwoods are reported in **Table 2;** shape S is usually used (10). Common tooth profiles are shown in **Figure 1.** The convex back reduces the clearance angle to a minimum and adds strength to the tooth. Mills that process hardwood logs containing silica normally use swaged and stellited saws. Typically, the saw is not used more than 3 hours without checking for faults.

Reported problems

Many reported problems are related to maintenance, such as the saw being used while dull, gullet bum while sharpening, incorrect and uneven tension, uneven crown, burrs left in gullet when sharpening, faulty wheel bearings, saw too thick for wheel diameters, and bandmill vibration. These problems result partially from a lack of skilled personnel in the shop and management (11). There has been no revolutionary development that would eliminate the need for highly skilled technicians and operators to obtain optimum results. In the future, the increasing inaccessibility of raw material sources may force decentralized processing to be integrated with logging, that is, mobile processing and power equipment.

Brazil

Forest resources

Brazil has 8.5 × 10^6 km^2 of forest resources. Of this, approximately 3.47 × 10^6 km^2 are tropical forest, which is about 30 percent of the world's total. Brazil's forests contain 15 to 20 percent of all known species (8). The forest-based industries in the Amazon region, primarily located on riverbanks, contribute approximately 4 percent to Brazil's Gross National Product (GNP) (30). About 60 to 70 percent of all woods in the Amazon region have a specific gravity greater than 0.70.

Principal problems of the wood processing industry in Brazil include the following:

•Highly selective nature of forest exploitation;

•Scarcity of qualified personnel at all levels;

•Obsolete equipment and inadequate maintenance infrastructure.

Too much emphasis is placed on a few species and too many trees are cut to get out the well-known, high-valued species (15). As the supply of traditional species gradually diminishes, new species enter the market that require greater processing care (4) as a result of high silica content, high density, or inordinate growth stress Some examples follow:

• Ipe *(Tabeuia* spp.): high density, an abundant species, difficult to cut, 0.85 to 0.97 basic specific gravity (18);

• Tauari *(Couratari guianensis, C. oblongifolia, C. pulchra):* silica, 0.50 basic specific gravity, up to 0.8 percent silica content in some species;

• Itauba *(Mezilaurus itauba):* high density and silica content, 0.96 basic specific gravity (18);

• Parajuba *(Dialium guianense):* high density and silica content, 0.81 to 0.93 basic specific gravity (3).

Sawmilling

From 1980 to 1991, Brazil's sawnwood production ranged from 7.7 to 9.3 × 10^6 m^3 (Table 1). Sawnwood production is primarily used for civil construction, furniture, building, joinery, and packaging.

Para State.— Para produces 30 percent of all timber in Brazil and 78 percent of all timber in Amazonia. Information from Armco Do Brasil (l), a manufacturer of sawblades, indicates that exports from Para comprise 50 percent or more of all timber exports from Brazil in recent years. Of the 4,000 mills in Para, Professor Lara (15) visited 400. One mill, Sawmill Betzel LTD, produces 35,000 m^3 of lumber per year. Lara observed logs being moved by bulldozers, not skidders, and estimated that 50 percent of the log is left in the forest. The company cuts only what the market demands. Lara divided the 400 mills he visited into three categories:

Small: 1 bandsaw producing 10 to 40 m^3 lumber per day;

Medium: 2 bandsaws producing 60 to 70 m^3 lumber per day;

Large: 3 to 5 bandsaws producing 90 m^3 or more per day.

Maranhao State.— The volume of lumber produced for three Cikel Sawmills in Maranhao combined is 50,000 m^3/year (5); recovery is about 55 percent; lumber dimensions are 25 and 60 mm thick, with various widths. Only part of the mill production is planed. They use a bandsaw for breakdown with a depth of cut ranging from 150 to 800 mm and a circular saw for edging and crosscutting. The sawblade geometry from samples sent to us from their mill at Maranhao is shown in Table 2. The saws are sharpened every 4 hours, and blades are tensioned by rolling.

Reported problems

In Lara's (15) opinion, the species of Para are different than in other areas of Brazil. The wood is hard and has a high moisture content, and the sawblade is the main limitation. As a result of difficulties, he often witnessed the saw being stopped in the cut. There are numerous blade losses, and blades are changed three or four times a day. The recovery can be very low, with perhaps 80 percent of the fiber lost, 60 percent in the forest and 20 percent in the mill, giving only 20 percent recovery on a log basis. Further, Lara noticed maintenance and safety problems, which the mill operators often denied.

In the opinion of Cikel Sawmill managers (5), the main problem with Brazilian sawmills is low utilization of saw capacity (low feed speed) because of under-powered equipment, inadequate tooth geometry, too much gap in saw guides, narrow blades, and poor tensioning.

VENEZUELA

FOREST RESOURCES

In Venezuela, the natural forest covers about 0.5×10^6 km^2, and logging activity is allowed on 50 percent of the forest area, mainly in the Guayana region. In addition, Venezuela has 0.005×10^6 km^2 of plantation Caribbean pine (29).

The timber industry in Venezuela is centered around a few species with commercial value that are easy to saw without technical improvement in the mills. Many less-used species are not processed because of the nonexistent marketing system and the availability of established commercial species. About half the production (368,857 m^3) is a result of forest management plans, the remaining (379,743 m^3) results from the traditional annual permits system (no management plan required) (25). A minimum diameter at breast height of 30 cm is required by law for a tree to be cut.

Common uses of sawnwood are construction, joinery, particleboard, plywood, pulp, paper, corrugated, and recycled fiber. The contribution of the forest sector to the GNP is less than 1 percent (16). Thirteen main species, basic specific gravity ranging from 0.4 to 0.91, have commercial interest.

Another species gaining importance because of its abundance is Chupon rosado *(Franchetella anibifolia), 0.70* basic specific gravity, which is difficult to machine because of its high silica content.

SAWMILLING

Data for lumber production are given in **Table 1.** The usual recovery from a sawlog in Venezuela is 60 to 70 percent in sawnwood of commercial dimension. In the pine plantation *(Pinus caribaea),* the recovery maybe close to 70 percent (24). These values seem unusually high, but the basis of computation is unclear.

Venezuela has 291 sawmills; almost all use bandsaws (23). The most common type of mills produce 20 to 25 m^3 of sawnwood per shift. Common tooth styles are wolf and gum. Most blades are spring set, commonly by hand. **Table 2 gives** the sawblade parameters recommended for high density wood (21 ,22). Saws are changed every 4 hours when cutting wood that is soft, but wood that is hard may require changing saws every 2 hours or less (both cases without stellite).

REPORTED PROBLEMS

In general, deficiencies exist in the maintenance of sawmills (24). The sharpener (sawfiler) has little training, learning only the empirical methods from the previous sharpener. Only a few species with silica are processed because only a few filers know about stellite and other techniques. These deficiencies make it difficult to introduce new species. The primary problem is that the species have a high density and are abrasive.

INDONESIA

FOREST RESOURCES

Estimates of natural forest area in Indonesia vary between 1.15 and 1.43×10^6 km^2 (14). The Bornean province of Kalimantan possesses the largest remaining forest area (34 %), followed by Sumatra (32 %), and Irian Jaya (26 %). Predominant species in the Kalimantan forests include meranti *(Shorea* spp), ramin, damar, and ulin; the Sumatrean forests are dominated by meranti, pine, mangroves, and ulin species. The composition of the forest resource in Irian Jaya is more heterogeneous than in the western Indonesia states, with nondipterocarp mixed hardwoods occurring prominently in the species mix.

Two abundant species that are difficult to process are Palapi *(Heritiera* spp.), 0.52 to 0.59 basic specific gravity, which contains silica, and Balau *(Shorea* spp.), because of its density (0.70) and interlocked grain (3).

The Indonesian forest industry sector places much emphasis on exports. Forest products exports account for 16 percent of the country's total export earnings (13), only behind petroleum and gas in importance. However, continued domestic industrial wood demand could conflict with export levels.

In 1987, an estimated 76 percent of wood production was used as fuelwood; about half was from personal fuelwood plots. The waste in logging may exceed the log volume extracted, perhaps more than 1.5 to 2 times, when considering the residual damage to the stand and the full range of log diameters (20). Seventy percent of sawnwood is consumed domestically. The domestic market helps absorb products that are not suitable for export.

SAWMILLING

Sawmilling is the oldest and largest primary forest industry in Indonesia, with about 2,700 sawmills operating. The major centers of production are found in Kalimantan and Sumatra, where about 83 percent of the Indonesian sawntimber production is realized; 63 percent of log consumption goes to sawmilling. The usable wood waste from sawmilling is about 8×10^6 m^3. Increased efficiency in wood usage could have a significant effect on the wood supply (13).

The main use of the sawntimber is building material and furniture manufacturing. Sawntimber production is export oriented, but domestic sawntimber consumption has increased each year, mainly because the quality and grade of the output often fall short of export requirements.

REPORTED PROBLEMS

Problems that have contributed to the low performance of the industry include inefficient production techniques and machinery, leading to low wood recovery ratios (less than 50 %); lack of skilled labor; and poor managerial skills (14).

MALAYSIA

FOREST RESOURCES

Malaysia is a leading producer and exporter of tropical hardwoods. The total forest area of Malaysia is about 0.2×10^6 km^2, 62 percent of total land area. In Sarawak, the forest cover is 77 percent, and in Sabah 60 percent. In Peninsular Malaysia where the conversion of forest into agriculture crops takes place at a high pace, 48 percent of the land area remains forest (9).

Nearly all logs produced in Peninsular Malaysia are consumed locally (mainly for sawntimber and plywood), and 80 and 90 percent of logs produced in Sabah and Sarawak, respectively, are exported. In 1988, sawlogs, sawntimber, and wood products were 12.9 percent of total gross export. The value-added contribution of the sector is small, only 5.1 percent of the GNP.

The following hardwoods exported from Peninsular Malaysia (19) are difficult to process:

- Balau *(Shorea* spp.): abundant, dense, 0.70 basic specific gravity, difficult to cut;
- Merbau *(Intsia bijuga, I. palemban - cia):* abundant, 0.68 basic specific gravity, gummy;

• Rengas *(Gluta* spp., *Melanorrhoea* spp.): silica, severe dulling (3).

SAWMILLING

Malaysia has 916 sawmills, of which 667 are in Peninsular Malaysia, 143 in Sabah, and 106 in Sarawak, Malaysia almost exclusively uses bandsaws for producing sawnwood. About 79 percent of the sawmills are in active operation. Throughout the industry, the average mill recovery rate is 54.5 percent (9). The major timber products in Malaysia are sawntimber, plywood (includes blockboard), veneer, moulding (includes dowels), woodchips, chipboard, wood furniture, builders carpentry, and joinery.

The single most important production unit of the Malaysian sawmill industry is a small bandsaw with wheel diameters ranging from 0.91 to 1.1 m, often used for both log breakdown and resawing.

The most common machinery of a Malaysian sawmill is a vertical log bandsaw, usually 1.83 or 1.52 m with a semiautomatic log carriage combined with generally six small resaws of the type previously mentioned. In general, the breakdown unit uses 203- to 254-mm-wide blades that run at approximately 1829 m/min., which is about the minimum saw speed necessary to cut tropical hardwood. Attempts of a decade ago to modernize and automate sawmills were not successful because of the variety of species and the log diameters to be processed, along with variable target sizes.

A typical 1.52-m band headrig used for log breakdown of different species has the characteristics given in **Table 2.** Teeth are stellite tipped, mostly alternately. The clearance angle is apparently kept high to reduce feed force and prolong the life of the tooth and blade.

The specifications of the small bandsaws usually used for resawing in the majority of the sawmills are also given in **Table 2.** All teeth are generally stellite tipped. Most saw-sharpening machines are not equipped with cams for changing tooth profiles, which might partially explain the predominant use of the flat-bottom shape **(Fig. 1).** Many experts argue that this shape is not the ideal tooth profile for cutting medium to high density species, but it has proved in many countries to be capable of meeting all basic requirements. Unless the sawmill industry is prepared to sort logs according to density groups and/or abrasiveness of species, there appears no need to introduce another tooth shape (28).

REPORTED PROBLEMS

The moulding, joinery, and furniture industries are facing difficulties in obtaining accurate dimensions of sawn material from sawmills (2). Although almost all sawmills have facilities for bandsaw maintenance, the typical sawfiler does not know the profile, tooth height, angles, swage, or other parameters about the saw.

CONCLUSIONS

Hardwood sawing technology and the related problems were identified in five tropical countries: Ghana, Brazil, Venezuela, Indonesia, and Malaysia. The density of wood and occurrence of silica make it a challenge to saw many tropical hardwoods. The bandsaw is the most commonly used machine and is employed in many sizes and configurations. Sawblade parameters and operating procedures vary according to the nature of the species being sawn and are influenced as much by local custom as technical knowledge of the process. The most commonly reported sawmilling problems include poor maintenance, lack of trained personnel, obsolete equipment, and inadequate sawtooth geometry and wear resistance.

The main opportunities for research appear to be in the areas of sawtooth geometry and wear characteristics. Information from Brazil referenced the blade and tooth geometry as problems. The high density and abrasive nature of species from Venezuela were given as limitations to processing, From Malaysia came the suggestion to review test results on "difficult" species and develop knowledge of factors influencing machining quality. If research can result in developments that reduce the need for highly skilled sawfilers, it would be a further benefit.

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