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# Balsa: biology, production and economics in Papua New Guinea

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Research that works for developing countries and Australia

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Cover: A plantation of balsa, six months old, Vudal, East New Britain
(Photo: Stephen Midgley)

# Foreword

The Australian Centre for International Agricultural Research (ACIAR) seeks to promote poverty alleviation and livelihood enhancement through more productive and sustainable agriculture emerging from international research partnerships. Papua New Guinea (PNG) is one of our most important partner countries. Communities living on islands in the Pacific face significant difficulties in developing successful economies. Transaction costs are of paramount significance—transport adds to the cost of all imports, including fuel, and detracts from the returns for goods produced, while the small size of individual communities increases dependence on external trade.

Crops that have high value and afford opportunities for local processing are especially important. They must of course be well adapted to the relevant environmental conditions, be amenable to production by smallholders as well as larger operators, mature within an acceptable time and, to the extent possible, have a stable market. Balsa is a crop that potentially meets these criteria for some areas in PNG. It is locally significant in East New Britain province (ENB), where high rainfall and fertile soils derived from volcanic parent material are conducive to rapid growth of high-quality wood on sites close to a port.

Most of the balsa traded globally is grown in Ecuador and exported to the United States of America, although markets in Europe, India and China have grown in recent years. Balsa wood is used in the marine, wind-energy and transport sectors, principally as core material in panels and other composites. Polymer foams compete with balsa in this application. As well as the level of global economic activity, issues of quality and elasticity of supply are very relevant to the competitive position and continued prosperity of the balsa industry.

Balsa cultivation is an attractive land-use option for smallholders and larger landowners in PNG, including cocoa growers affected by cocoa pod borer. ACIAR supported this scoping study with a view to identifying researchable issues across the PNG balsa value chain—issues whose resolution, by the industry itself, by partnerships involving ACIAR, or by other agencies, will underpin the continued viability and potential expansion of PNG's balsa wood industry.

Using a careful blend of literature review, interviews with key industry stakeholders and economic analysis, this study provides background biological information, a summary of the historical and current status of the balsa industry, and explores the relative merits of the three main balsa production systems in PNG. The study concludes with a series of recommendations for research and development that would assist the PNG balsa industry to sustain productivity and competitiveness in the global market.

Nick Austin
Chief Executive Officer, ACIAR

# Contents

# Abbreviations

| | |
|---|---|
| A$ | Australian dollar |
| ACIAR | Australian Centre for International Agricultural Research |
| AEV | annual equivalent value |
| CST | candidate seed tree |
| ENB | East New Britain province |
| FEU | 40-foot container |
| FMA | Forest Management Agreement |
| FOB | free on board |
| IRR | internal rate of return |
| ITTO | International Tropical Timber Organization |
| LAES | Lowland Agricultural Extension Station |
| NANDINA | Andean Trade Community Standard Product Code System |
| NARI | National Agricultural Research Institute |
| NPV | net present value |
| PFMC | Provincial Forest Management Committees |
| PGK | Papua New Guinea kina |
| PNG | Papua New Guinea |
| PNGFA | PNG Forest Authority |
| PNGFRI | PNG Forest Research Institute |
| R&D | research and development |
| UNRE | University of Natural Resources and Environment |
| USA | United States of America |
| US$ | United States dollar |

# Currency (August 2009)

| | | |
|---|---|---|
| PNG kina | = | PGK |
| A$1.00 | = | PGK2.11 |
| US$1.00 | = | PGK2.63 |

# Acknowledgments

The global balsa markets are not well documented, and reliable information was challenging to locate. Many generous people helped in assembling this report and deserve special mention.

In Papua New Guinea (PNG), the fieldwork would not have been accomplished without competent support from our local coordinator, Mr Tommy Kosi, and the cooperation of the balsa growers on the Gazelle Peninsula who gave their time during a busy period in the agricultural calendar.

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Mr Titi Darius, Chairman, and Mr Paul Arnold, Executive Officer, of the PNG Growers' Association (ENB Branch) organised a public meeting of growers and facilitated discussions on balsa and its global markets. Professor Phillip Siaguru, MBE, Vice-Chancellor, University of Natural Resources and Environment, and Dr John Moxon of the Lowland Agricultural Extension Station of the National Agricultural Research Institute, at Keravat, provided access to information and facilities. Mr Harry Sawicki, General Manager, ENB Port Services Ltd, offered background on the challenges of shipping from Rabaul.

The processing companies were generous with their time and information: Guy and Catherine Cameron at PNG Balsa and their team; Mr Graeme Stowell and Mr Paul Aisawa at the GSMC/Auszac Balsa Alliance; Mr Gunter Isensee of Gunter Balsa Ltd; Mr Peter Hooper (the former General Manager), Mr Mike Jackson, Mr Bob Wilson and Mr Anthony Rainbird at Coconut Products Limited.

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# Summary

Balsa (*Ochroma pyramidale*, syn. *O. lagopus*) is a fast-growing, pioneer subtropical and tropical tree that produces very low density wood widely used for a range of commercial purposes. It is a medium-sized tree that grows to 25 m in height and 1 m in diameter, deciduous or evergreen and occurring in both pure and mixed stands in association with other pioneer species. Balsa is widely distributed across its natural range from 22°N to 15°S in broadleaf evergreen and secondary forests in Central and South America. It has been introduced to many tropical countries, including Papua New Guinea (PNG) where it thrives on sites with high uniform rainfall and good-quality, well-drained soils. It is grown in plantations on 5–7-year rotations and now forms the foundation of a small and expanding industry in East New Britain province (ENB) where there an estimated 3,500 ha has been planted.

Due to its low density, strength and versatility, balsa is suitable for a wide range of end uses. It is used extensively for hobbies, model-making and surfboards and other sporting equipment. Its main industrial use, and the use that forms the largest part of the global balsa market, is as end-grain panels. These are widely used as components of structural sandwich panels consisting of low-density core material sandwiched between two high-modulus face skins to produce an exceptionally stiff and light composite panel. The features of balsa that are attractive to manufacturers of sandwich panels are its relatively low price compared with competing core materials, and its:

- green and renewable credentials—balsa is the only core material derived from a natural and renewable resource
- wide operating temperature range (–212 °C to +163 °C; –414 °F to +325 °F)
- excellent fatigue resistance
- good sound and thermal insulation
- high impact strength.

Innovation has become the hallmark of successful companies that use balsa wood, and balsa has found applications in many market sectors, as outlined below.

*Marine:* As a lightweight and strong composite, end-grain balsa has been used in hulls, decks, bulkheads, superstructures, interiors, tooling and moulds. Many power boats, recreation craft and commercial vessels have components made from balsa composites. Balsa has been used for the massive, static-free insulation in cryogenic transport ships (used for shipping liquefied natural gas).

*Road and rail:* Key engineering considerations in road and rail engineering include low weight combined with rigidity and strength, and acoustic and thermal insulation as well as fire safety. Balsa is found in many modern railway carriages in lightweight composite panels in ceilings and compartment walls. The cabin flooring, roof panels, body panels, interiors, front-ends and side skirts of popular makes of trucks and buses are balsa composites.

*Wind energy:* Balsa is used in lightweight cored sandwich panels that improve the performance and efficiency of wind-turbine rotor blades. Wind energy represents one of the most promising applications for environmentally friendly balsa.

*Aerospace:* Balsa panels are used in flooring, galley carts, interior partitions, cargo pallets and containers, and in parts for sports aircraft.

*Defence:* The defence industries have long had an interest in balsa and balsa products. Balsa is used as a standard core material in present-generation naval ship structures where sandwich composites with balsa cores feature in applications such as surface ship deck structures, radar masts and boat hulls. The panels forming emergency and tactical shelters (including field hospitals) commonly use balsa cores, and the standard cargo pallet for defence air transport is made with a balsa core.

*Industrial:* Balsa-cored composites are widely used in ductwork insulation for industrial pipes, as insulation for cool stores, in tooling, tanks, impact limiters, concrete forms, fascia panels, skis,

snowboards, wakeboards and lightweight packaging material for fragile goods.

It is estimated that in 2008 the global trade in sawn kiln-dried balsa wood and semi-finished wood products was 155,000 $m^3$, worth an estimated US$71 million. Ecuador supplies almost 90% of this trade and PNG 8%, with producers in Colombia, Brazil, Venezuela, Costa Rica and Indonesia making small contributions. The United States (US) market is the world's largest for balsa products, accounting for some 80% in 2001 but falling to 51% in both volume and value in 2008. In 2008, Ecuador supplied 94% of US imports of balsa. While the US market has been relatively uniform in terms of volume imported for the past 10 years, imports to China, India and Europe have expanded substantially. The marine, wind-energy and transport sectors have been major drivers of the expansion of global markets. Investments in expansion of balsa plantations and processing facilities indicate confidence in the outlook for global balsa markets, with some industry participants forecasting annual market growth of around 7%.

In 2009, the Australian Centre for International Agricultural Research (ACIAR) commissioned a scoping study that sought to protect the interests of smallholder growers and processors of balsa in PNG by identifying researchable issues associated with current opportunities for and threats to the industry (ACIAR Project No. FST/2009/012: 'Identification of researchable issues underpinning a vibrant balsa wood industry in Papua New Guinea'). This report details the results of the study.

Balsa cultivation is an attractive and competitive land-use option for landowners, including smallholders in ENB. There are few barriers for new entrants to balsa production, although an inadequate labour supply appears to be a limitation, especially for smallholders. Three growing systems are common in ENB: independent smallholders, large landholders and grower groups. Balsa production in ENB is moving steadily away from smallholder-based systems towards larger-scale production systems, including landowner grower groups managed under share-farming arrangements with processing companies. Larger-scale production systems, including share-farming arrangements, provide a more reliable and continuous supply of quality balsa resources to processors. While each production system is profitable, the large-scale plantations and integrated grower–processors generate the highest returns, associated with use of improved silviculture and labour management practices that generate higher yields, wood quality and prices. Share-farming production systems offer substantial benefits to growers while the production, marketing and sovereign risk is carried by the processor.

The balsa industry in ENB currently provides direct employment for about 3,000 people and this will increase once the expanded plantation resource matures. The capacity of the PNG industry to expand and thrive is finite and constrained by international market demand and the industry's capacity to remain competitively engaged with these markets.

Globally, the balsa industry faces serious challenges from the greater use of polymer foams in sandwich composites. Innovation and research and development (R&D) are vital to an assured future for balsa products. For PNG to maintain its global competitiveness and increase market share, it must strengthen its reputation for quality, reliability and responsiveness and ensure that plantation production and processing are strongly aligned with profitable global markets.

In response to these challenges, PNG's balsa industry could be assisted through a focused program of R&D support aiming to:

- improve productivity and wood quality through wider application of improved silvicultural practices
- support changes to issues relating to governance, ensuring that government regulations add value to, and do not impede, efficient functioning of the supply chain
- add transparency to the supply chain and ensure that social issues relating to production are understood
- assist in developing and maintaining markets for balsa from PNG.

# Papua New Guinea: its geography, forestry sector and population trends

## The context of Papua New Guinea forests

Papua New Guinea (PNG) includes the eastern half of New Guinea, the islands of New Britain, New Ireland and Bougainville, and hundreds of smaller islands (Figure 1). The total population in 2009 was estimated at 6.7 million (SPC 2008) and the land area is about 463,000 km$^2$, of which only 27% is peopled. The country is usually divided into the islands, the lowlands (0–1,200 m) and the highlands (1,200–2,800 m), although more specific regional classifications are also used. People live throughout this entire altitudinal range, with about 40% of the rural population living in the highlands region. Almost 50% of the total land area is mountainous and 20% is seasonally or permanently flooded. High rainfall, long dry seasons and excessive cloud cover are other common constraints to agricultural development (Hanson et al. 2001).

PNG is endowed with a very large area of forests—forest cover is estimated at 29 million ha, or nearly two-thirds of the total land area and includes some of the richest flora and fauna in the world and contains several highly valued commercial timber species. The forests are classified as: 80% rain forests, 4% moist forests, 5% woodland and 11% montane forests. The coasts host some of the most extensive mangroves in the region. The country has about 10.5 million ha of forest that might be considered permanent; these include 8.7 million ha of forest over which timber rights have


**Figure 1.** Papua New Guinea

been acquired ('permanent forest estate'), 1.7 million ha allocated for protection and an estimated 60,000 ha of timber plantations.

Estimates of the rate of deforestation in PNG vary but loss of forest cover was reported at 0.4% annually between 1990 and 2000; some non-government organisations (NGOs) report higher rates. Much of the deforestation is due to conversion to land uses such as agriculture, increasingly for oil palm plantations (ITTO 2007b).

While the principle of sustainable forest management is enshrined in the PNG Constitution of 1975, the sector has been plagued with serious challenges to uphold it. Most legislation and regulations have been enacted as a result of forest degradation and problems associated with logging operations and trade, as well as dissatisfaction of landowners, donors and NGOs. Although legislation includes substantive social and environmental aspects, the emphasis has always been on logging operations and especially economic returns.

The 1991 Forestry Act introduced new allocation procedures and a new administration system. It established the PNG Forest Authority (PNGFA) and mandated it to manage the nation's forest resources through implementing the overall objectives of the National Forest Policy. It operates through the National Forest Board, the National Forest Service and the Provincial Forest Management Committees, among other bodies. The Forestry Act empowers PNGFA to negotiate Forest Management Agreements (FMAs) with resource owners, to select developers (concessionaires) and to negotiate conditions under which Timber Permits, Timber Authorities and Licences may be granted. Supported by the National Forestry Development Guidelines, the National Forest Policy was devised as the operational arm of the Forestry Act, mostly for administration and control of the forest sector.

The National Forest Board oversees the activities of PNGFA. Its composition, as outlined in the Forestry Act, includes representatives of all actors in the forestry sector.

The National Forest Service is the agency responsible for administering the Forestry Act. It is in charge of practically all aspects of forestry at the national level in PNG. Often the responsibilities overlap both within the service and with the Department of Environment and Conservation, which is mandated to oversee all aspects of forestry operations that impact on the environment—including approval of FMAs.

The responsibilities of the Provincial Forest Management Committees (PFMCs) include, among other things, ensuring proper consultations with customary landowners. The PFMCs, however, are constrained to some extent by shortages of human and financial resources.

## Land ownership

Most rural people live on their own land, which they acquire under customary title and clan systems. Customary land accounts for about 97% of the total land area of PNG, but governments do not formally administer this land, and title documents are not issued. Some formal settlement schemes have been developed, particularly in association with cash crops such as oil palm. Here, people do have formally registered title on their land which makes them eligible for bank loans to fund housing and cash-crop development.

The system of land tenure plays a critical role in sustainable forest management in PNG because most forests are owned by customary landowners. There is, however, a common reluctance by customary owners to register their title to the land, compounded by vaguely defined boundaries of ownership. While the state has no ownership rights over land or its forest resources, the government (through PNGFA) acquires private (customary) property rights in the public interest for forest development. Landowner participation in the negotiation and granting of FMAs is among the points of contention in the system of granting forest logging licences. On the other hand, it is difficult for any forestry administration to manage privately owned land even if mandated to do so.

## Employment trends in Papua New Guinea

According to the PNG Statistics Office, the national workforce in 2000 was around 2.4 million workers out of a total population of 5.2 million. More recent data are not available as the national census is conducted every 10 years. With an annual population growth rate of 2.7% (AusAID 2007), the estimated population in 2009 for PNG would have been about 6.6 million. According to the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP 2008), the labour force is growing at a slightly lower rate of 2.4% a year. At this rate, it is estimated that there would have been almost 3.0 million persons in the workforce in 2009.

Most of the workforce in PNG are involved in what is described as non-monetary employment where there is no payment for labour. This reflects the high rural population in PNG and the numbers of people involved in subsistence and semi-subsistence farming activities. Some of these people are active in the informal economy, selling their surplus production in local markets. In 2000, over 76% of the workforce was involved in non-monetary employment (Gumoi 2005).

A shortage of skilled labour is a concern throughout PNG, especially in rural areas. Wages tend to be lower in rural areas, encouraging skilled workers to relocate to the larger urban centres where they can earn higher incomes. Within rural areas, underemployment is considerable and opportunities for formal employment are few compared to urban areas. Some centres attract migration from other parts of PNG. Migrants relocate to seek better access to services, more productive environments and opportunities for paid employment provided by the towns and plantations. East New Britain province (ENB) has been attractive to people from other PNG provinces because of the presence of these conditions (Hanson et al. 2001).

## Cultural characteristics of workers

For many workers in PNG, their experience in the paid workforce is relatively short and their attitude and behaviour towards work is strongly influenced by their traditional culture. Imbun (2006) described three workforce involvement strategies in the mining industry in PNG. He noted that most miners have no previous paid employment experience. These conditions may be relevant to labour in the forest industries, although this is yet to be verified. The three strategies described by Imbun (2006) are:

- *The tribal strategy*—generally unskilled and semiskilled workers with low commitment to work; involvement in paid employment is secondary to tribal commitments; typically, employment is aimed at accumulating enough money for specific tribal activities such as paying bride prices, for tribal ceremonies or for settling differences; they value the skills that they acquire that may be applied to future business ventures.
- *The entrepreneur strategy*—characterised by workers involved in paid employment while simultaneously operating small businesses; these workers are semi-committed to industrial work while maintaining a strong commitment to their land, tribe or village; they may be a high-risk group for employers.
- *The worker strategy*—generally better-educated workers with a strong commitment to their jobs; employment is their sole source of income and they tend to be committed for the long term, although they have not cut ties with their villages.

Kavanamur (2001, p. 9) found that cultural characteristics in PNG require business managers to tailor human resources management policies, managerial practices and interpersonal communications accordingly. Distinguishing cultural characteristics[1] identified by Kavanamur include:

- low individualism / high collectivism—individuals perform tasks primarily to build relationships with superiors, friends, family and clan networks, referred to as *wantokism* in PNG
- high uncertainty avoidance—individuals avoid uncertainty or ambiguity and are unwilling to show initiative on the job as it is not encouraged or rewarded; they depend on authority structures and develop an external orientation—that is, they prefer to follow clear instructions within an authoritarian or paternalistic environment
- low abstract thinking / high associative thinking—explanations of events or decisions are derived from unrelated events rather than from cause–effect relationships—in cultures where associative thinking dominates, there is often no logical basis to the association among events
- past–present time perspective—short-term oriented with little long-term thinking, which may be linked to the unpredictable and difficult environment; for example, Varmola (2002) identified PNG landholders' preference for expediency, seeking short-term solutions to long-term investment issues
- passive/reactive task orientation rather than proactive and forward looking (which is relevant to development, investment and savings).

These characteristics of PNG workers may present unique challenges for employers.

[1] While these characteristics define features of the culture in PNG they are not unique to PNG; they are common in many developing countries.

Kavanamur (2001, p.10) proposed that 'managers need to understand society's attitude towards human nature and towards work, time and space'. The high labour intensity in balsa growing and processing in ENB places considerable importance on labour management and employer–employee relations to ensure commitment, stability and productivity in the industry.

## East New Britain province[2]

ENB comprises about 15,100 km$^2$ of the island of New Britain, in the north-east of PNG (Figure 2). The Gazelle Peninsula is in the north of the province and encompasses the Baining Mountains, the valleys of the Keravat and Warangoi rivers, numerous smaller rivers and narrow coastal plains. In the north-east of the Gazelle Peninsula are fertile hills and plains that surround the Rabaul volcanoes. The area is densely settled and well developed.

Past volcanic eruptions have covered the area in fertile volcanic ash but, in 1994, eruptions caused widespread damage to infrastructure, cash crops and water supplies. The province also includes the Duke of York Islands which are 20 km north-east of Kokopo (the current capital of ENB), and Watom Island which is 10 km north of Rabaul (the provincial capital until it was largely destroyed by the 1994 volcanic eruptions). There are four administrative districts in ENB; Gazelle, Kokopo, Pomio and Rabaul (Hanson et al. 2001).

Average annual rainfall varies from 2,000 mm near Kokopo to over 5,000 mm on the south coast. There are moderate dry seasons in the north-east of the Gazelle Peninsula. Table 1 gives climate details for Rabaul.

The estimated population of ENB in 2000 was 247,000, which is 6% of the national population. The estimated population in 2009 was around 314,000 based on the national annual growth rate of 2.7%. This may be a conservative estimate, as the provincial rural population growth rate is very high—4.2% per annum. The highest population

2 Information extracted primarily from Hanson et al. (2001)

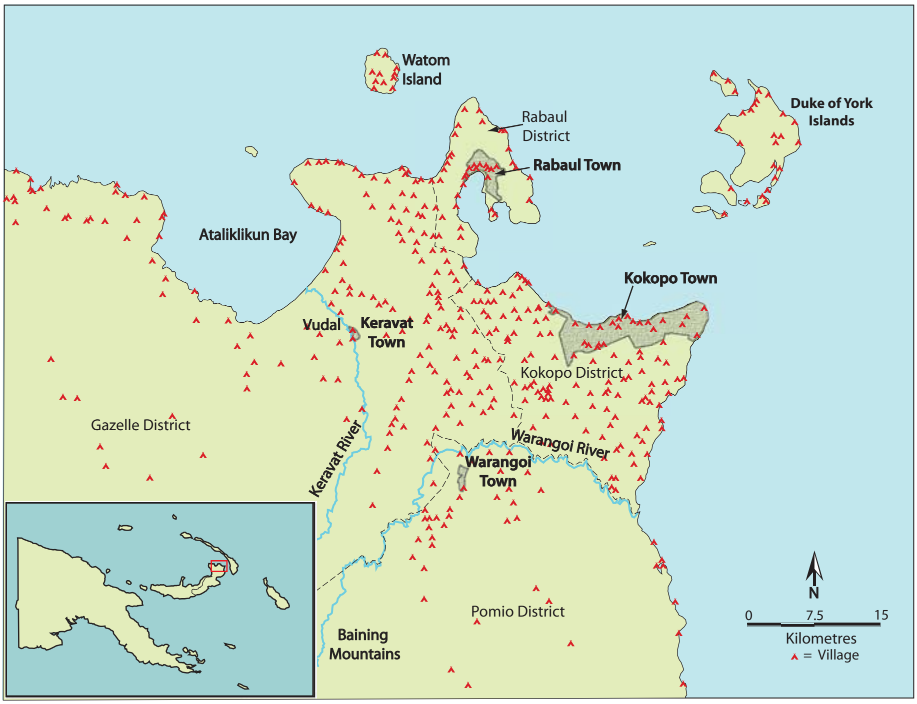


**Figure 2.** East New Britain province, including location within Papua New Guinea (inset)

densities are on the volcanic hills and plains of the Gazelle Peninsula, in the Duke of York Islands and on Watom Island, with an average of 220 persons/km$^2$. There is significant in-migration in the north-east of the Gazelle Peninsula, with people from many parts of PNG seeking better access to services, more productive environments and paid employment opportunities provided by the towns and plantations.

## Gazelle district

The main area for growing balsa is the Gazelle district in the north-west of the Gazelle Peninsula and the adjacent volcanic plains and hills. Altitude varies from sea level to over 1,000 m in the Baining Mountains.

The estimated population in the Gazelle district in 2000 was 93,000 and possibly reached around 118,000 in 2009. The highest population density of 220 persons/km$^2$ was on the volcanic plains and hills. The Baining Mountains, the northern coastal plains and valleys, and the western coastal plains support densities of 23 persons/km$^2$, while the lower Keravat and Warangoi valleys have lower densities of 10 persons/km$^2$. The western half of the district is mostly unoccupied. The volcanic plains and hills have significant in-migration. The population of the Toma and Central census divisions increased by an average of 8% per annum between 1980 and 1990.

There is a network of sealed roads on the volcanic plains and hills. Gravel-surfaced roads connect centres on the northern coast to the western Baining Mountains.

Incomes are high to very high on the volcanic plains and hills, on the coast of Ataliklikun Bay and in the lower Keravat and Warangoi valleys, and are derived from the sale of cocoa, betel nut, fresh food and copra. People in the Baining Mountains earn low incomes from the sale of fresh food, while those on the northern and western coasts earn very low incomes from minor sales of cocoa, copra and fresh food. Other sources of income in the district are small-scale enterprises such as cocoa fermenting, trade stores and construction, and also paid employment by businesses and plantations. Small numbers of people in the Baining Mountains receive wages and royalties from forestry operations.

Agriculture on the volcanic plains and hills is dominated by intensive banana cultivation. Triploid bananas can produce for 20 years if they are managed properly. People make two consecutive plantings before a fallow period of 5–10 years. Coconut is also an important food. Agriculture in the area to the south-west is similar but less intensive. People in the Baining Mountains and on the northern and western coasts cultivate low-intensity mixed-staple gardens. In the 1982–1983 National Nutrition Survey, malnutrition in children under 5 years old was assessed as relatively low.

The land potential is high to very high on the volcanic plains and hills, on the coast and inland valleys of Ataliklikun Bay, and in the Keravat and Warangoi valleys. The very high potential land is among the most productive in PNG. Rainfall, soils, slope, light and temperature are ideal for the production of many crops, but gullying and soil erosion are problems in some places. The Baining Mountains

**Table 1.** Rabaul monthly rainfall, temperature and humidity (Source: McAlpine et al. 1983)

| Attribute | Month | | | | | | | | | | | | Annual[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
| Rainfall (mm) | 230 | 244 | 256 | 209 | 129 | 114 | 104 | 103 | 94 | 118 | 173 | 228 | 2003 |
| Mean max temp (ºC) | 30.9 | 30.9 | 27.0 | 30.8 | 31.2 | 30.9 | 30.4 | 30.7 | 31.4 | 31.6 | 31.3 | 30.9 | 30.7 |
| Mean min temp (ºC) | 23.2 | 23.2 | 23.3 | 23.3 | 23.6 | 23.3 | 23.2 | 23.2 | 23.4 | 23.3 | 23.3 | 23.2 | 23.3 |
| Mean (ºC) | 27.1 | 27.1 | 27.0 | 27.1 | 27.4 | 27.1 | 26.8 | 27.0 | 27.4 | 27.5 | 27.3 | 27.1 | 27.1 |
| Humidity index[b] | 85 | 86 | 86 | 86 | 84 | 84 | 83 | 81 | 79 | 81 | 82 | 86 | 84 |

[a] Total/averages may differ from sum/average of rows due to rounding.
[b] The ratio of average 0900 vapour pressure to the saturation vapour pressure at the average mean temperature. This is regarded as a good approximation to the daily mean (24-hour) relative humidity.

have very low to moderate potential due to steep slopes, poor soils and frequent cloud cover, while the northern and western coasts have low potential constrained by poorly drained, shallow soils and frequent flooding.

There is no agricultural pressure in the district. The potential for further development on the volcanic plains and hills is limited by existing development and very high population densities. At present, people are squatting or leasing land for subsistence agriculture and there are concerns with soil erosion on the steeper slopes. There is potential for agricultural development where land potential is moderate to very high and access to markets is good. Cocoa, betel nut and fresh food are established smallholder cash-earning activities in these areas.

Overall, people in the Gazelle district are not disadvantaged relative to people in other districts of PNG. There is some agricultural pressure, land potential is very high, access to services is very good and cash incomes are comparatively high.

# Employment trends in East New Britain

Workforce statistics for ENB are not readily available, but based on the national ratio of numbers in the workforce to total population, the workforce could have been around 145,000 in 2009, including around 54,000 in the Gazelle district. If 70% of these are involved in subsistence agriculture, then the number in paid employment could be around 15,000. However, depending on employment strategies practised by workers in the district, the number could be more than twice this. The statistics indicate that labour availability is high.

Within PNG, most people are employed in the informal economy, especially in rural areas. Most people are engaged in subsistence and small-scale cash-cropping activities. Men tend to be responsible for cash cropping while women concentrate on food production. According to Newlin (2000), the more successful male cash croppers are those who can mobilise the labour of their wives. The opportunity for paid employment is often limited by the lack of adequate infrastructure to allow access to places of employment. In the Gazelle district, there is a good network of sealed roads that allows people reasonable access from their villages to commercial centres and places of employment.

The Tolai people are the traditional inhabitants on the Gazelle Peninsula. They are regarded as being among the best educated and most prosperous of Papua New Guineans, a status that is linked to their early association with Europeans and the establishment of the German administrative centre in Rabaul in the late 19th century (Newlin 2000). According to Newlin, the Tolai are inclined towards capitalism and commercial practices as a consequence of their long experience using a universal, divisible currency and their involvement in the labour trade with Queensland, Australia, in the 19th century.

## Household labour management strategies

Household labour and livelihood strategies of smallholder cocoa growers in ENB were studied by Curry et al. (2007). Their research (and previous studies) found that most smallholder households rely on unpaid family labour for cocoa production. They also found that, despite the large size of families in ENB, labour shortages are a major constraint to increasing production. Labour shortages may be associated with one or more of the following factors:

- lack of cooperation among household members in cocoa production
- illness or death of family members disrupting work schedules during mourning periods
- reduced access to labour from the extended family
- increased size of cocoa holdings with insufficient family labour relative to area of cocoa planted
- rising cost of hired labour (there is limited and sporadic use of hired labour, usually for specific tasks including harvesting, establishment and rehabilitation of cocoa)
- high mobility (out-migration) of family members, especially males.

In the case of cocoa production, Curry et al. (2007) argue that understanding household income and labour strategies is important for explaining productivity because of the high dependence on family labour and reluctance to use hired labour. The same is likely to be true for smallholder balsa production. Some relevant findings from this research for balsa are:

- Social and kinship responsibilities attract smallholders' time and labour away from cash-generating activities such as cocoa or copra production (14–20% of time on a weekly basis). Paid employment is exclusively the domain of men, albeit a small share of total labour time (less than 2% per week).

- Around 35–40% of time is allocated to crop production and marketing activities, while 6% is for subsistence gardening, 14% for rest and around 20% for domestic duties, including child care.

Curry et al. (2007, p. 53) concluded that the various non-production demands on labour time result in labour shortages for cocoa production. Gender division of labour for particular activities may also constrain labour supply. The consequence of this is that crop management inputs are limited and productivity is low relative to potential yields. An adequate supply of labour is critical to high levels of production.

Key characteristics of households with an adequate supply of labour for cocoa production were identified by Curry et al. (2007, p. 62). These are presented in Table 2.

In the case of cocoa, families that are unable to mobilise adequate levels of labour from within the family, through reciprocal exchanges or by hiring are more likely to adopt a wet-bean production strategy than a dry-bean production strategy. While the wet strategy is less labour intensive than the dry-bean strategy, returns are lower as well.

Parallels may be drawn for balsa production from the cocoa household labour management strategies. The effect on productivity and timber quality associated with different labour management strategies is worthy of further research.

# Development of plantations in Papua New Guinea

## Introduction

Papua New Guinea's forest plantations are a relatively minor forest resource compared with the nation's natural forests. Now that most of PNG's accessible commercial forest areas have been allocated and are being harvested, however, interest in the potential of plantations is increasing. The first commercial plantations were established in PNG in the 1950s, although since then development has been sporadic, with plantations scattered over a wide geographic area. Adams (2007) reported that there are plantations at about 20 different sites in 10 provinces. Most plantations are located within reach

**Table 2.** Characteristics of smallholder cocoa-growing households with an adequate supply of labour (Source: adapted from Curry et al. 2007)

| Characteristic | Comment |
|---|---|
| Access to labour of unmarried and/or married sons | Good working relationships within the family facilitate labour mobilisation and commitment of individuals |
| Reside in multi-generational and extended family units (houses clustered together) and with multi-household production units (for subsistence and cash cropping) | |
| Household works cooperatively and harmoniously as a family group | |
| Household is willing to utilise indigenous mechanisms of labour mobilisation when necessary to maintain cocoa production during high crop periods | This may involve adoption of children or recruiting relatives to live with the family; it may also involve reciprocal labour-exchange agreements among households for intensive tasks such as planting, grass slashing, harvesting and processing.<br>These strategies are independent of paid labour, although cash and food gifts may be exchanged.<br>The success of reciprocal labour exchanges depends on the skill of the household heads. |
| Few intra-household disputes over labour remuneration | Family members satisfied that distribution of cocoa income is fair and frugal |
| Household head allocates cocoa harvests or cocoa beans to adult household members and other relatives | Head builds goodwill (social capital) by allocating harvest proceeds to family members, allowing him to draw on their unpaid labour support when needed |

of established infrastructure including good roads and port and/or processing facilities. Plantations have been established without government incentives or other direct forms of industry support.

The PNG Government has had little success with policies and other measures to attract investment in plantation development (Adams 2007, p. 32). The National Forest Policy that was implemented in 1991 proposed that 'programmes for plantation development will be guided by economic criteria and feasibility studies to assess the commercial potential of processing plantation material for a variety of end uses' (The Independent State of Papua New Guinea 1991, p. 7). The policy also proposed that woodlot establishment, agroforestry and tree planting 'will be promoted and supported by active forestry extension'. Draft policies for reforestation, eco-forestry and downstream processing have been developed and once endorsed by the government promise increased focus on plantation development, domestic timber processing and opportunities for small-scale forest production and processing.

## Area of forest plantations

According to PNGFA data, there were about 62,000 ha of plantation forests in 2005 (PNGFA 2005), up from 58,000 ha in the mid-1990s (PNGFA 2002). The most recent assessment of the status of forest resources in PNG was conducted in 1997 as part of the Forest Inventory Mapping System. These inventory data have been adjusted in later years, although 'there has been no systematic attempt to update or ground-truth inventory data' (ODI 2007, p. 10). A review of the potential, achievements and challenges to the PNG forestry sector by the International Tropical Timber Organization (ITTO 2007b) found that national- and provincial-level plans were based on 'guesstimates' of forest area and other key statistics. The review recommended that a national forest inventory be conducted and maintained on a regular basis. At the request of the PNG Government and with the support of the ITTO, Malleux and Lanly (2008) assessed implications of inventory design to meet the needs of policymakers and other stakeholders and prepared an action plan for the development of a multipurpose national forest inventory. PNGFA has been allocated funding to carry out the inventory in 2009–2010.

An ITTO (2005a) report on the status of tropical forest management estimated that there were 80,000 ha of plantation forest in PNG in 2005. This estimate assumed an annual planting rate of 4,000 ha, based on data provided to ITTO by PNGFA. Anecdotal evidence suggests that this is likely to be an overestimate. More realistic estimates would be around 50,000 ha. Until the scheduled national forestry inventory is completed, however, figures for the area of forest plantations remain unreliable. At best, the official PNGFA data provide an indication of the area of land that has been allocated for forest plantations. In addition, there are 16,670 ha of rubber plantations in PNG (including industrial plantations); areas planted by villagers and plantations established as part of settlement schemes (Bourke and Harwood 2009).

Anecdotal evidence from selected sites in PNG indicates that a range of plantation management strategies is being practised. For example, in the Gogol Valley near Madang, replanting of *Acacia mangium* by smallholders has not kept pace with harvesting due to lower than expected returns and changes in harvesting arrangements. Estimates of the current area of acacia plantations are less than half of the original 12,000 ha. At Open Bay in ENB, *Eucalyptus deglupta* plantations have expanded by more than 50%, reaching almost 20,000 ha in 2008 (SmartWood 2007). In Morobe province, the rate of replanting of the araucaria plantations after harvest at Bulolo has been limited in recent years by termite infestations and limited fire control. PNG's teak plantations have been heavily harvested in response to strong export demand. Several of the remaining stands of teak are of poor form (Adams 2007, p. 32). There has been little reported establishment of new plantations in PNG since the mid-1980s.

## Species

The main plantation genera grown in PNG are *Eucalyptus, Acacia, Araucaria* and *Pinus*. Eucalypts, which comprise around 45% of the total area planted, are dominated by *Eucalyptus deglupta* that is exported as roundwood and sawn timber. The main acacia species is *Acacia mangium,* which comprises 20% of PNG's total forest plantation area. Acacia is processed into woodchips and exported through the Madang port. Together, *Araucaria* and *Pinus* comprise 28% of the total area and include species such as *Araucaria cunninghamii* (hoop pine), *Araucaria hunsteinii* (klinki pine), *Pinus caribaea* and *P. patula.* Timber resources from these forests are processed into various products including plywood, treated poles, sawn timber and prefabricated buildings for the domestic and export markets. Other important species include *Tectona grandis* (teak), balsa and *Terminalia* sp. The importance of balsa has increased in recent years, as the area of plantations in ENB increased from an estimated 700 ha in 2003 to 3,500 ha in 2009. This trend is not reflected in the official plantations data.

## Investment patterns

Investment in plantation development has been dominated by the private sector—more than 60% of plantations are in private hands. This figure reflects investment in industrial-scale plantations by large national and international companies. It does not include the plantings of scattered trees and small woodlots of individual farmers and villages. There is potential to link smallholder growers to industrial-scale plantations and timber processing and marketing operations though various arrangements including the nucleus estate system that is common for oil palm in PNG.

Trees have been integrated into customary land-use systems in PNG for a range of purposes including meeting household food and fuelwood needs, protecting cash crops such as coffee and cocoa, supplying building materials and to provide a direct source of income. Trees are grown as part of the home garden, in woodlots or in agroforestry systems (e.g. *taungya*—the practice of raising a forest crop in conjunction with a short-term agricultural crop). Trees grown in home gardens offer a supply of food, fuelwood and building materials over the short to medium term, depending on the length of the garden's fallow period. Trees grown in woodlots are for the supply of fuelwood and timber resources for the construction of houses and other buildings over the medium to long term. Trees grown in agroforestry systems provide a range of goods and services, including timber resources for various end uses and non-timber products such as fruit, nuts and oil. For example, in coffee and cocoa production systems, tree genera such as *Albizzia*, *Leucaena* and *Gliricidia* are used as nurse crops. Once they have served their primary purpose, they are harvested for home consumption as fuelwood (Hunt 2006). The diversity and dynamism of these systems reflect high levels of innovation and adaptation in agriculture by PNG landholders (Kanowski et al. 2008).

Subsistence food production and shifting cultivation characterise agricultural production systems in PNG, with locally grown food supplying 80% of calories consumed by rural people. According to Hanson et al. (2001, p. 11) 'most gardens are low-intensity shifting cultivation systems, which operate on cycles of 1 or 2 years of cropping, followed by 5 to 15 years of fallowing'. During the fallow period, the land reverts to bush that must be cleared by hand to recommence the cycle. The fallow period in the shifting cultivation cycle offers promising opportunities for agroforestry systems.

## Constraints to development

Kanowski et al. (2008) identified a number of constraints to development and expansion of commercial tree growing in PNG, including:

- *infrastructure development*—poor physical and market infrastructure including roads, timber-processing capacity, port services and market information systems
- *financial competitiveness*—long lead times before a positive cash flow is achieved, lack of reliable information on financial aspects of tree growing and lack of access to suitable credit services
- *access to technology*—limited availability of suitable planting material and relevant technical knowledge, including extension services
- *threat of loss*—risk of fire in grassland or adjacent environments or loss through theft.

Varmola (2002, section 3.2.3) concluded from a study of hardwood plantation establishment in Pacific island countries that a key to 'the success of commercially driven plantation development and management is the management attitude'. Two forest management types were identified for PNG—plantation foresters and indigenous foresters. Plantation foresters treat a plantation as a series of renewable tree crops, while indigenous foresters perceive any forest, planted or natural, as a resource rather than a crop. The consequence of this is that indigenous foresters tend not to apply any silvicultural management to a planted forest. Furthermore, as they do not manage a plantation as a series of crops, they may withdraw after the first rotation, having achieved a household income goal or being disillusioned by lower-than-expected returns. This attitude and behaviour of indigenous foresters is exacerbated by a number of factors including:

- *expediency*—PNG culture is generally expedient (Varmola 2002); while this may be attractive to investor partners, the culture assumes that deals are negotiable; therefore, landowners may seek short-term returns or solutions to long-term investments after a deal has been agreed
- *inexperience*—participation by smallholders in plantation developments is often encouraged by expectations of attractive returns promoted by developers and advisors; but smallholders' unfamiliarity with the vagaries of the market economy and the value of silvicultural management may result in lower-than-expected returns and consequently their withdrawal from subsequent forest plantation activities.

The level of taxes and duties and trade restrictions imposed on forest resources may also restrain plantation investment, especially for some species. The government's log export tax was imposed in an attempt to recover a share of the logging revenues that company taxation failed to capture. The export tax does not apply to plantation logs or processed timber products, which effectively acts as an inducement to plantation and timber-processing investment. However, exports of selected species (including balsa, teak and all conifers) as roundwood are banned, even though they are grown in plantations. The definition of roundwood includes wood stripped of sapwood or roughly squared (i.e. not downstream processed, such as sawn timber). The export ban requires that these species are processed before export.

## Growth potential

As resource supplies from natural forests decline and pressures increase to protect remaining natural forests, investment in plantations is expected to increase in PNG. ITTO (2007b) proposed that plantations are needed for a number of reasons, including:

- creating employment opportunities for rural people
- developing competitive export production
- encouraging economically viable downstream processing of forest products
- ensuring opportunities for the entire community to participate in the development process.

While acknowledging the potential for plantation expansion, Hunt (2006) noted that government funds and suitably qualified personnel to support expanded programs are limited. AusAID (2006) concluded that 'while there is obvious potential in the land-abundant Pacific countries for large plantations, land tenure constraints mean that the greatest potential for plantations may be at the community or household level'.

Despite the existence of incentives and other forms of government support, evidence from PNG and other Pacific island countries indicates that investment in plantations does not occur unless it is profitable over the long term and critical risks can be satisfactorily mitigated. The main risk is resource security. Varmola (2002) and Hunt (2006) propose that private investment is easier to attract once a plantation resource is established and is at or near maturity. They argue that the role of government should be to establish and manage forests on customary land leased from owners. As the planted resource approaches maturity, the lease is transferred from government to the highest-bidding private operator. Under this management scenario, the government's agency focuses on maximising the quality of the plantation resource while the private company focuses on investment in processing facilities and restocking the harvested lands.

PNGFA (2009, p. 41) reported that the government's intention is to increase the area of plantations in PNG in line with the current draft reforestation policy, which the government is yet to endorse. Key drivers of the policy are future domestic and export market timber demand and the government's commitment to the clean development mechanism of the Kyoto Protocol (PNGFA 2005).

PNGFA (2009, pp. 37–38) identified many weaknesses that have to be overcome to ensure that forestry in the future will be based on sustainable forest management. These included the need for: more education and awareness-building for tribal communities to allow them to make better-informed decisions; increased financial and human resources for government institutions responsible for forestry; and good overall political governance. This is a future where the role of the government is an enabling one rather than engaging directly in forest management. PNGFA saw the role of government in ensuring a better future for the industry as providing basic community needs such as education and health services, improving transport and communication infrastructure and facilitating rural development. Furthermore, PNGFA (2009, p. 38) expects that when the policies on reforestation, eco-forestry, downstream processing and climate change are endorsed by government 'the country may see a shift from large-scale commercial forest exploitation to smaller projects that will be more beneficial to people and the environment'.

# Biology, forestry and uses of balsa

## Natural balsa forests

Balsa (*Ochroma pyramidale*, syn. *O. lagopus*) is a fast-growing pioneer tree species that produces very low density wood that is used for a wide range of commercial purposes. It is a medium-size tree, deciduous or evergreen, occurring in both pure and mixed stands in association with other pioneer species. The boles of mature trees are generally cylindrical and straight, with buttresses on older trees. Balsa is widely distributed across its natural range from 22°N to 15°S in broadleaf evergreen and secondary forests in Central and tropical South America (Figure 3). The name 'balsa' is derived from the Spanish word for 'raft'.

### Natural distribution

The climate in balsa's wide natural range is humid tropical with annual rainfall of 1,500–3,000 mm with a short (<4 month) dry season. The mean temperature of the coldest month varies from 20 °C to 25 °C and the mean temperature of the hottest month varies from 24 °C to 30 °C (Francis 1991). Balsa is not frost tolerant and it grows from near sea level to 1,800 m above sea level in Colombia.

Balsa grows best in well-drained, alluvial soils along watercourses and this is where it is most commonly found, although it can colonise clayey, loamy and silty soils and even fresh road fill. Natural stands of balsa can be found both on flat areas and steep slopes.

Growth of balsa is very fast in its natural habitat, with mean annual diameter increment up to 10 cm and, after 10–12 years, when growth stabilises, trees can be 25 m tall and 1 m in diameter. After 12–15 years of growth, the trees begin to deteriorate rapidly (Wiselius 1998).

### Taxonomy

*Ochroma* is a monotypic tropical American genus in the family Bombacaceae. CABI (2005) suggests the current nomenclature is *O. pyramidale* although

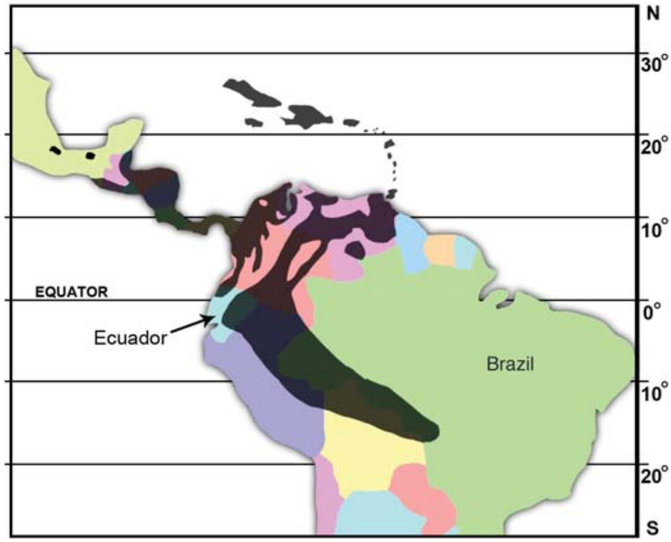


**Figure 3.** Natural distribution of balsa (shown in black) (after Francis 1991)

the species has often been referred to as *O. lagopus* in the literature; a name in universal use before 1920. The balsa of Ecuador was named *O. grandiflora* by Rowlee in 1919. Herbarium material from Ecuador, however, is not specifically different from West Indian material. The balsa of the West Indies has two scientific names, both dating from 1788; *O. lagopus* Swartz and *O. pyramidale* (Cav.) Urban. Other scientific names for this species include *Bombax pyramidale* Cav. ex Lam., *Ochroma bicolor* Rowlee and *O. concolor* Rowlee, reflecting a considerable morphological diversity across its natural range. Fletcher (1951) acknowledged that as many as 11 species were recognised in early literature.

## Genetic variation and conservation status

Given experience with other widely occurring tree species, it is inevitable that species such as *O. pyramidale*, which occurs across a broad natural range in Central and tropical South America, will possess considerable genetic variation. This study[3] has been unable to locate any detailed assessments of genetic variation or data recording broad-scale provenance assessment.

As an abundant pioneering species demonstrating excellent regeneration throughout its range of natural occurrence, balsa is not biologically threatened. The international trade in balsa wood is legal, but larger companies (such as Plantabal SA, Alcan Baltek's Ecuador plantation company) are seeking certification for their plantations to ensure access to global markets. In a study for the United Nations Environment Programme (UNEP) World Conservation Monitoring Centre, Gillett and Ferriss (2005) reported no concerns as to the conservation status of the species in Mesoamerica.

## Floral biology and seed production

In its natural range, balsa begins to flower at 3–4 years of age; under plantation conditions trees can begin to flower and set seed after 3 years (CABI 2000) and in PNG flowering can occur after 9 months, although producing few viable seeds. The trees flower annually and flowering time varies over the natural range—in August in Ecuador (Fletcher 1951) and more generally between December and February in Central America where the fruits (pods) mature rapidly over 2 months from mid-January to early April (Anon. 2009a). Under uniform conditions of high humidity, flowering can occur throughout the year. Balsa is bisexual and night-flowering and the flowers are pollinated by bats; at least five species of South American bats are known to pollinate the flowers (Alley-Crosby 2009). The large white flowers (Figure 4) are held upright on the tree and the large (25 cm long and 3 cm in diameter) mature cylindrical pods are green. The small seeds are embedded in a matrix of silky fibres that aid wind and water dispersal. There are 150,000–170,000 cleaned seeds/kg.

## Balsa as a weed

Balsa's abundant seeding habit and ease of propagation confer a strong capacity to quickly colonise disturbed habitats. Balsa is considered to be invasive in the Pacific islands (Meyer and Malet 2000) and in some situations it has become naturalised and formed dense, closed-canopy, nearly monospecific stands that shade out other species, and/or compete for water and sunlight, suppressing growth and regeneration of understorey plants.

## Management of natural forests for wood production

Balsa from native forests was the primary source of balsa in 1951 (Fletcher 1951). Today, some 15% of Ecuador's production is derived from native forests. In natural stands, balsa regeneration can be profuse following burning or other site disturbance, and requires heavy thinning if trees are to offer commercial crops. At 3–4 months, seedlings are thinned to 2,000 per ha, followed by thinning at 1.5, 2.5 and 3.5 years (Francis 1991). In Ecuador, traditionally, trees were cut at age 6–8 years in natural forests, debarked by hand and dragged to the riverside using bullocks. Logs were then transported to the mills by water (Fletcher 1949). Fletcher (1951) noted that the logging operations in native forest harvests were very wasteful.

[3] Throughout this report, 'this study' refers to the scoping study 'Identification of researchable issues underpinning a vibrant balsa wood industry in Papua New Guinea' (ACIAR Project No. FST/2009/012), commissioned by the Australian Centre for International Agricultural Research. Its output is this report.

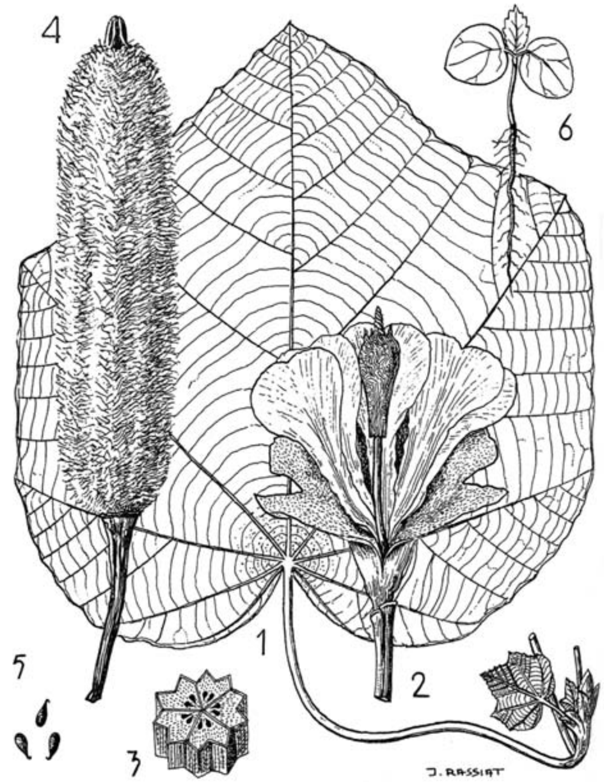


**Figure 4.** Key botanical features of balsa (not all at same scale): (1) leaf, lower surface; (2) open flower with unfolded calyx and corolla, traces of bracts; (3) cross-section of a fruit before maturity; (4) mature fruit; (5) seeds; (6) seedling, approximately 1 month old (Source: Anon. 1961)

## Balsa plantations

The broad commercial markets for balsa wood and the ease with which the tree can be propagated and managed have resulted in plantations being established in many parts of the tropical world. Plantations have been recorded in 10 countries outside its natural range (including Indonesia, Sri Lanka, West Africa, Solomon Islands and Papua New Guinea (CABI 2000)) and Costa Rica, Mexico, Bolivia, Brazil, Colombia, Venezuela and Ecuador within its natural range. As a general guideline, preferred plantation sites have lowland, humid tropical conditions, uniform annual rainfall of about 2,500 mm and deep, well-drained soils. Ecuador has the world's largest plantation estate with an estimated 18,000 ha and PNG, which provides 8% of global supply, has some 3,500 ha. Smaller plantation estates meet industry needs in Indonesia, Colombia, Costa Rica and Peru.

### Silviculture and management

Detailed silviculture guidelines are offered in *The balsa manual: techniques for establishment and the management of balsa* (Ochroma lagopus) *plantations in Papua New Guinea* (Howcroft 2002) and in Ochroma lagopus: *silvicultural characters and plantation methods* (Anon. 1961).

Nursery guidelines for balsa propagation are provided in Anon. (1961), Wiselius (1998) and Howcroft (2002). Balsa is normally propagated by seed, with little commercial success in vegetative propagation being recorded. Some growers dibble seed into prepared plantation sites but the most common method of plantation establishment is via nursery-grown seedlings. The roots of young trees are very susceptible to damage, so bare-rooted plants cannot be used (CABI 2000). Therefore, where seedling transport is difficult, direct sowing of seed is often the preferred method of establishment.

In PNG, seed may be collected throughout the year with a peak during April–November (Howcroft 2009) or June–August (Wiselius 1998), and in Ecuador seed is collected from October to November. The seeds are orthodox and retain viability for as long as 6 years in sealed containers at room temperature, although cold storage at 4 ºC is recommended. Francis (1991) reported that germination can be improved in many ways: a hot water soak for 20 minutes, a boiling water soak for 2–3 minutes; a soak in coconut water for 12 hours; or scarification and exposure to dry heat (96 °C) for 5 minutes. Seeds are sown in boxes or in plastic pots, in a 1:1 mixture of sandy loam garden soil and pure fine sand—a soil media combination which can give a high germination percentage. Light shade is given to prevent excessive moisture loss.

When seedlings are about 20 cm tall (at about 3–4 months of age) they are transplanted into holes of 30 cm × 30 cm × 30 cm, at a spacing of about 4–5 $m^2$ (CABI 2000). Initial spacing varies and is influenced by the need to maximise the growth rate of each tree which, in turn, influences wood density (Wiselius 1998).

Careful tending is necessary during the first year, as the seedlings are quite fragile and can be easily damaged by wounding and browsing. Seedlings cannot survive weed competition in the first year. Nurse crops are useful to guard against excessive bark scorch. Epicormic buds should be removed. Protection against fire is also necessary (CABI 2000).

In some plantation situations, the trees are interplanted with agricultural crops at the time of establishment. A *taungya* system at 2 m × 3 m spacing can be used (Wiselius 1998). In PNG, a closer initial spacing (2.5 m × 2.5 m; 1,600 trees/ha) is recommended where unimproved genetic material is used (Howcroft 2002), with thinning to 1,260 stems/ha 1.5 years after planting, and a commercial thinning to 630 stems/ha at age 3.5 years. When genetically improved planting material is used, an initial spacing of 4 m × 4 m is used. At year 5–6, the plantation is clear felled and replanted. In reality, growers in PNG plant balsa at various stocking rates, varying from 2.5 m × 2.5 m to 3 m × 4 m depending on the site, resources and labour for weeding, interest in thinning and availability of seedlings.

Early growth in balsa plantations is extremely rapid, with annual height increments for the first 2 years exceeding 3 m. Well-formed trees in PNG plantations can reach a diameter at breast height (dbh) of 30 cm some 30 months after planting.

Rotation lengths vary with site conditions and management intensity. It is rare for rotation lengths to extend beyond 8 years as growth slows appreciably between 7 and 12 years. At this stage, heartwood development starts and, with a much higher density and a darker colour, it is less suitable for commercial purposes (Wiselius 1998). In PNG, a rotation length of 5 years is common and the risk of the occurrence of 'red heart' (a wood colouration) increases with rotations beyond 6 years (Howcroft 2009). In Indonesia, a rotation length of 8 years is used (Wiselius 1998), in Costa Rica 4–6 years (Revel 1993) and in Ecuador 6–7 years is commonly adopted (DIAB, Ecuador, pers. comm.).

*Ochroma pyramidale* is a very strong light demander, but tolerates some lateral shade in the first year in sites where the summer sunlight is strong. It has the ability to self-prune. Where plantings from some seed sources are highly branched, pruning of green branches is recommended before 12 months of age (Howcroft 2002).

## Tree improvement and deployment of high-quality germplasm

This study has been unable to locate any reports of widespread and comprehensive collections of balsa from its range of natural occurrence and subsequent assessment in provenance trials. Given the taxonomic complexity and morphological variation within *O. pyramidale,* it is highly likely that considerable genetic variation exists in key characters such as growth, form, wood density, internode length and pest and disease resistance. Such variation offers considerable opportunities for selection and deployment of improved germplasm. To date, there has been no commercial success in developing vegetative propagation techniques for the species and this limits options for capturing genetic gain. Another challenge facing tree improvement is the floral biology of the species—with bats pollinating the night-blooming flowers, control of pollinating vectors is challenging.

A modest program of tree improvement has functioned sporadically in PNG since 1980 (Figure 5, and see below) and the company Alcan Baltek reportedly uses improved sources of seed for its plantations in Ecuador. Indonesia reportedly has a balsa improvement program. Commercial success of any tree crop requires use of the most appropriate high-quality germplasm. It costs just as much to establish a tree from poor seed as it does from seed of the highest quality, yet the differences in growth and quality and financial returns can be dramatic. Although details of other tree improvement programs for balsa were not found during this study, it is likely that they have been established and opportunities exist for collaboration.

**Figure 5.** A select ('plus') tree of balsa in Papua New Guinea (Photo: Stephen Midgley)

## Wood quality

Balsa is a very low density wood and is the lightest and softest of all commercial timbers (Eddowes 2005). The heartwood (not often used as commercial timber) is pale brown or reddish and the sapwood (forming most commercial timber) is nearly white or oatmeal-coloured, often with a yellowish or pinkish hue (USDA, undated). Trees are harvested before full biological maturity to avoid the development of coloured heartwood.

Commercial balsa wood usually ranges in density from 100 kg/m$^3$ to 170 kg/m$^3$ but can vary from 50 kg/m$^3$ to 410 kg/m$^3$ (Francis 1991). Wood density and other properties can vary greatly depending upon origin and growth conditions (CIRAD 2003), with fast-grown trees reportedly producing a greater proportion of low-density timber (PNG Balsa, Kokopo, ENB, PNG, pers. comm.). Because trees grow more slowly as they age, density increases linearly with distance from the pith and height above the ground (Whitmore 1968).

Balsa wood of varying densities has a modulus of rupture of 148–372 kg/cm$^2$, a modulus of elasticity of 300,000–62,000 kg/cm$^2$ and a maximum crushing strength of 63–64 kg/cm$^2$ (Francis 1991).

When harvested at 4–6 years, there is little or no heartwood in the log and no growth rings. Logs have a pith of about 2 cm in diameter that can 'wander' through the centre of the log and which must be removed during sawing. Balsa's fast growth can lead to growth stresses, resulting in splitting during conversion. This can be minimised through use of twin saws at primary conversion. Balsa dries quickly with very little degrade, and kiln-drying, particularly of thicker stock, yields a much better product than air-drying. Kiln-drying normally takes the moisture content down to 10–14% over 2–3 days; detailed schedules are offered by USDA (undated), CIRAD (2003) and Eddowes (2005).

The wood is not durable and is vulnerable to drywood termite attack, and logs and green lumber are readily attacked by pin-hole borers. The sapwood is permeable (CIRAD 2003).

Blue-stain fungus is a significant source of commercial degradation and can develop in the wood if there are delays between harvesting, sawing and drying. In PNG, balsa is harvested, sawn and dried within 3 days to prevent blue-stain degradation.

Almost all balsa-processing operations segregate balsa wood into three density classes. While these classes vary in nomenclature and value between processors, they are generally described as: light (80–120 kg/m$^3$), medium (120–180 kg/m$^3$) and heavy (180–220 kg/m$^3$). This study was unable to locate markets for balsa wood with densities exceeding 220 kg/m$^3$.

Like most hardwoods, balsa is short-fibred, but is not used commercially for pulp and paper-making.

## Uses of balsa wood

Due to its low density, strength and versatility, balsa is suitable for a wide range of end uses. It is used extensively for hobbies and model-making, including models of boats and ships, aeroplanes, gliders and buildings. Due to its buoyancy, it is used for surfboards and has been used for life rafts and lifebelts. The technical standards for model balsa are very high, with clients demanding uniform light-coloured wood, free of knots and other defects and cut to precise dimensions.

Its main industrial use, and the use that forms the largest part of the global balsa market, is as end-grain panels. End-grain panels are widely used in sandwich panels (Figure 6), which are normally a low-density core material sandwiched between two high-modulus face skins to produce a lightweight panel with exceptional stiffness. The face skins act like the flanges of an 'I' beam, carrying tensile and compressive loads. The core plays the role of the web, separating the face skins and carrying the shear loads (Alcan Baltek 2009). The core materials provide panel thickness, with associated stiffness, at minimal weight. Stiffer panels require less support structure, simplifying structural design.

To prepare end-grain panels, harvested balsa is air-dried and then kiln-dried to 10–14% moisture content, with industry norms at 12%. The dried lumber is planed, cut to length and precisely measured and weighed to determine density. After segregation into density classes, the lumber is glued together, pressed into large blocks and cut into sheets with the wood fibres oriented perpendicular to the face of the core sheet. This end-grain orientation offers very high compression and shear properties, fundamental for good sandwich construction (Black 2003) and extremely high strength and stiffness-to-weight ratios.

In preparing end-grain balsa panels, manufacturers place considerable importance on the density and uniformity of the panel. Most buyers have very strict specifications and, for example, will allow only a certain number of defects in an end-grain panel. Colour is important for some applications, with a pale straw to white colour preferred.

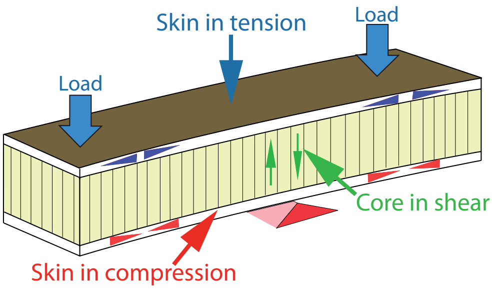


**Figure 6.** An end-grain panel used in a sandwich composite (Photo: Stephen Midgley)

The moisture content of panels is important, as high moisture contents (>14%) can interfere with the curing of adhesives used when applying the outer skins to the sandwich composites. Delamination between the outer skin and the core can be a major cause of product failure.

The features of balsa that are attractive to manufacturers of sandwich panels are its relatively low price compared with competing core materials, and it:

- is an ecological product—balsa is the only core material coming from a natural and renewable resource
- has a wide operating temperature range (–212 °C to +163 °C; –414 °F to +325 °F)

- has excellent fatigue resistance
- offers good sound and thermal insulation
- has high impact strength (Alcan Baltek 2009).

Balsa wood performs very well in fire-critical applications. It does not offer much fuel, and it burns with a nontoxic white smoke. If the wood does come into contact with flame, a uniform char layer forms that protects unconsumed core material from the heat source. In contrast, some competing core materials made from synthetic foams may produce fumes that contain toxic by-products (Black 2003). For these reasons, balsa is approved in most transit applications and as insulation for engine rooms.

Balsa achieves an excellent bond with most types of resins and adhesives and is compatible with a variety of manufacturing processes. While balsa is used as rigid panels, many fabricators prefer flexible sheet material in which the panel is cut into small squares held together with a fabric (mostly fibreglass) scrim backing that allows the core to conform to a curved, moulded surface.

As a core material, balsa has found a wide range of applications in many industrial sectors as outlined below. Examples of such applications are illustrated in Figure 7.

## Marine

As a lightweight and strong composite, end-grain balsa has been used in hulls, decks, bulkheads, superstructures, interiors, tooling and moulds. The Australian racing yacht *Scandia* had a hull made from a balsa composite. Many power boats, recreation craft and commercial vessels also have components made from balsa composites. Balsa has been used for the massive, static-free insulation for cryogenic transport ships (used for shipping liquefied natural gas (LNG)). The use of balsa in the marine field is not new—native South Americans were using it for rafts before European occupation. The raft used in the famous Kon-Tiki expedition of 1947 was made from balsa logs.

## Road and rail

Important criteria in rail vehicle engineering include weight saving while maintaining rigidity and strength, and acoustic and thermal insulation as well as fire protection. Because of their lower cost and better durability, infused, balsa-cored, fibreglass-skinned panels have replaced phenolic honeycomb-cored laminates in the floors of Bay Area Rapid Transit (BART) trains that operate in the greater San Francisco metropolitan area (Black 2003), and many modern railway carriages use lightweight balsa panels in ceilings and compartment panels. The flooring of the cabins of popular makes of trucks and buses are balsa composites, as are roof panels, body panels, interiors, front-ends and side skirts (Alcan Baltek 2009). Many modern trailer homes include sandwich composites that incorporate end-grain balsa, and some motion-picture production trailers, where weight is an issue, use balsa panels.

## Wind energy

Improving technologies have increased the performance and efficiency of wind turbines, and balsa is used as lightweight, cored sandwich panels in increasingly larger blades. In areas of rotor blades where high shear and compression strengths are required, end-grain balsa cores provide some of the cheapest and most reliable solutions. Wind energy represents one of the most promising applications for environmentally friendly balsa, with most turbine blades being constructed to provide a 25-year life.

## Aerospace

Among the best-known aerospace applications for balsa was its use in the Mosquito bomber in World War II, a cleverly designed aircraft built largely from wood. Some of the most famous aircraft manufacturers such as Boeing and McDonnell Douglas have used (and are using) balsa panels as floor panels, galley carts, interior partitions, cargo pallets, containers and general aviation (sports aircraft) parts.

## Defence

The defence industries have long had an interest in balsa and balsa products. During World War I, balsa was used in life vests and the British used the wood in 80,000 floats that supported their mine barrage in the North Sea. Balsa wood is used as a standard core material in present-generation naval ship structures, and sandwich composites and balsa cores feature in a number of applications, such as surface ship deck structures, radar masts and boat hulls (Mantena et al. 2008). The sandwich composite used generally consists of brominated vinyl ester resin with glass or carbon reinforcement and a balsa core (Sorathia and Perez 2005).

The panels forming emergency and tactical shelters (including field hospitals) commonly use balsa cores. The standard cargo pallet for defence air transport (274 cm × 224 cm; 108 inches × 88 inches) is made with a balsa core. The Royal Australian Air Force imports about 300 balsa-based cargo pallets annually worth about A$1,700 each.


**Figure 7(a–e).** Examples of products that embody balsa: many vehicles include panels with balsa cores, such as the floor panels of the Cadillac XLR (a), structural bodywork of the Toyota IMTS bus (b), the cab floor of the Kenworth T2000 truck (c), the hull and deck of the Dehler 47 yacht (d) and various sections of the Viking 74 sports fishing boat (e).

## Industrial

Balsa-cored composites are widely used in ductwork insulation for industrial pipes, as insulation for cool stores, in tooling, tanks, impact limiters, concrete forms, fascia panels, skis, snowboards, wakeboards and lightweight packaging material for fragile goods.

Innovation has become the hallmark of successful companies which use balsa wood.

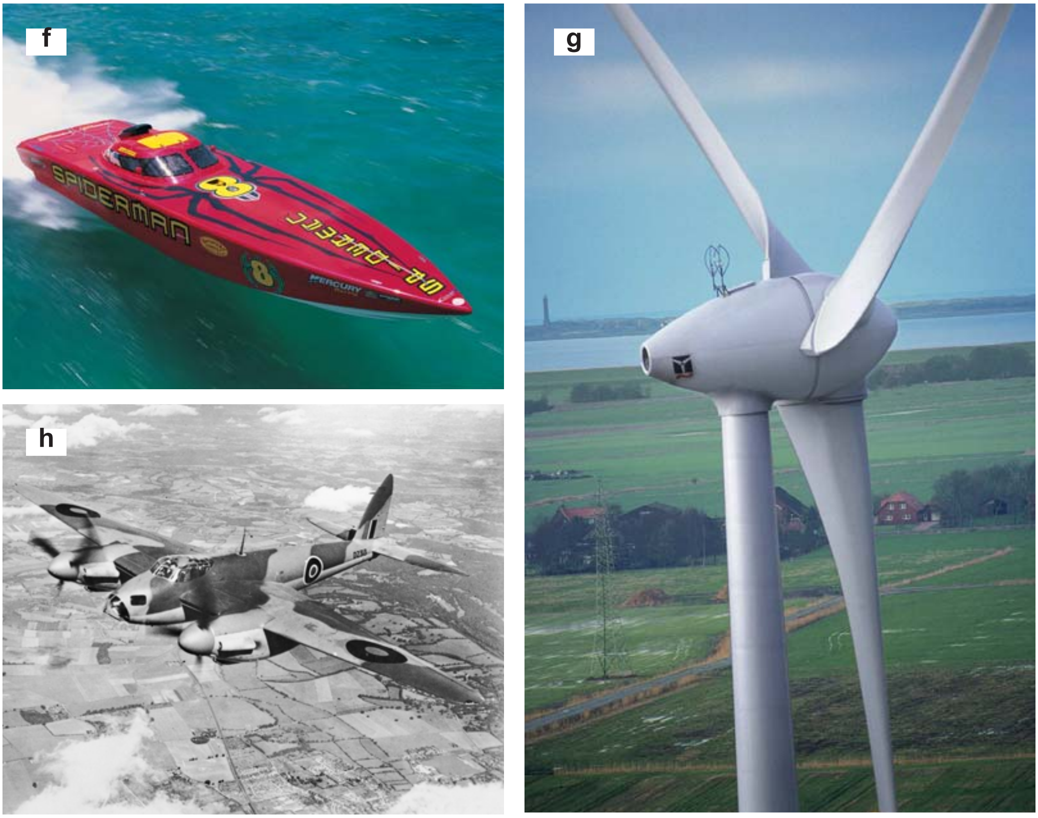


**Figure 7(f–h).** Examples of products that embody balsa: the hull and deck of the Douglas Marine Spiderman (f); end-grain balsa cores are used in rotor blades for wind turbines (g) where high shear and compression strengths are required; historically, the de Havilland Mosquito bomber of World War II incorporated balsa into its famous wooden construction (h). (Photos: a–f, Alcan Baltek; g, ENERCON; h, The Australian War Memorial)

# The balsa growers

Balsa has been cultivated, harvested and processed in all countries where it occurs naturally. In addition, it has been grown and processed in West Africa, Indonesia, Sri Lanka, PNG and Solomon Islands. From available trade data, it appears that the dominant global producer is Ecuador. PNG ranks second and there is reported but unquantified production from Costa Rica, Venezuela, Colombia, Peru and Indonesia. Unsubstantiated reports suggest that 4,000 ha of commercial plantations have been established in Mata Grosso, Brazil. While balsa will grow well in many parts of the world, the key to economic success appears to be proximity to processing facilities and links with international markets.

## Balsa in Ecuador

Ecuador is the world's dominant supplier of balsa and has been so for over 60 years; Fletcher (1949) noted that Ecuador controlled 95% of global production in 1943 and the United Nations Conference on Trade and Development (UNCTAD 2001) reported that Ecuador satisfied 80% of the world demand for balsa in 2001. This study indicates that, in 2008, Ecuador accounted for 89% of the global supply of balsa.

Ecuador lies on the north-western coast of South America and has an area of 276,841 km$^2$ and a population of 14 million. For a large part of the past 30 years, life in Ecuador has been marred by political instability. Protests in Quito have contributed to the mid-term ouster of Ecuador's last three democratically elected presidents. In September 2008, voters approved a new constitution; Ecuador's 20th since gaining independence. In 1999–2000, Ecuador suffered a severe economic crisis and the United States (US) dollar was adopted as legal tender. Despite a recovering economy, the government defaulted on several commercial bond obligations in 2008. The economic uncertainty generated by these actions has caused private investment to drop and economic growth to slow. Its 2008 exports of petroleum, bananas, cut flowers, shrimp, cacao, coffee, hemp, fish and wood (including balsa) totalled an estimated US$19.4 billion (CIA 2009).

Balsa occurs naturally in Ecuador and is grown primarily on the moist tropical coastal plains and hills (Figure 8) where the annual rainfall is about 2,500 mm. It has been utilised for a long time and was commonly used for rafts by the Incas over 500 years ago (Fletcher 1951). A significant part of commercial production comes from managed secondary balsa regrowth on cleared land or on abandoned banana or cocoa plantations—regeneration so profuse on some occasions that it is known as 'the weed tree' (Fletcher 1949). Balsa plantations began to be established in 1937 after the Ecuadorian Government passed a law requiring planting of two balsa seedlings for every tree cut for commercial use, and by 1940 three commercial plantations had been established (Fletcher 1951).

The plantation estate of balsa has steadily increased in recent years. Pastor (2004) reported that Ecuador had 8,000 ha of commercial plantations in 2004, and FAO (2006) reported 12,000 ha of balsa plantations in Ecuador in 2006. However, ITTO (2005b) reported that, in 2005, balsa, a major export timber from natural forests, was planted 'on a limited scale'. Vásquez (2005) reported that, in 2003, balsa production from plantations represented 85% of the total balsa log harvest of about 200,000 m$^3$, indicating a productive plantation base of about 5,000 ha at that time.

Since 2006, there has been a continuing expansion of the balsa plantation resource and export figures for 2008 indicated that the productive plantation base had reached 18,000 ha in that year.[4] The reasons underpinning this expansion include:

- recognition by growers that balsa cultivation is technically straightforward and can be a profitable enterprise

[4] Based upon an estimated export of 137,956 m$^3$ of balsa product and assumptions of an average conversion rate of 23% from green logs, a 6-year rotation and harvest yield of 200 m$^3$/ha.

- extension services from government, public institutions and foundations offering technical support and providing seeds free of charge
- new government legislation and regulations requiring the private sector to play a larger role in plantation investment—for example, companies are obliged to plant one tree for every one they cut. This is a continuation of ongoing government policies and incentives to establish plantations (Anon. 2001)
- legislation requiring landholders to cultivate their lands or face fines or resumption by the government
- bank credit to stakeholders across the balsa value chain—to farmers (to plant balsa trees), to businesses involved in harvesting and haulage, and to small processing factories.


**Figure 8.** The main balsa production areas of Ecuador (Source: after Bonet et al. 2009)

The expanded plantation program is reportedly assisted by a revitalised level of technical support from research institutions, companies and others to help improve productivity and quality in plantations and processing.

Although industry sources suggest that a significant part of this expanded resource is in areas with limited access or far from processing facilities, it indicates that Ecuador will remain the leader in global balsa supplies. It is common practice to establish more plantations than needed to ensure continuity of supply to processors in case of cut roads or infrastructure failure.

Smallholders and small plantations form the basis of the Ecuadorian supply of balsa and have found balsa cultivation to be very profitable. Smallholders have been encouraged to plant balsa in 1–3 ha blocks in association with cassava, bananas, orito (a type of small banana) or maize to revegetate areas of abandoned cropland (Sandu 2009). Small plantations are typically 20–30 ha with 625–830 plants/ha, managed on rotations of 4–5 years and often grown in association with an agricultural crop. Growers are encouraged to grow their balsa close to roads to reduce extraction costs (Anon. 2009b). Small commercial plantation operations can produce their own seedlings and regular weeding, thinning and control of unspecified insects and fungus constitute a large part of the costs of growing balsa.

The largest commercial grower in Ecuador is the Alcan Baltek company which, through its subsidiaries Plantabal and others, has an estate of 7,000 ha of well-managed plantations (see Box 1). Other major companies involved in the international balsa market, such as DIAB and Balseurope, also have their own plantations associated with their balsa-processing facilities in Ecuador.

Industry sources report that, typically, processors will purchase green, rough-sawn flitches (about 2.2 m × 150 mm × 100 mm) at the mill door for about US\$144/$m^3$. There are very strict specifications regarding size, density, knots or presence of 'blue stain'. Based upon log harvest and export figures, log recoveries appear to be 25–30% (Vásquez 2005). Most of Ecuador's processing and export-oriented activities are based around the port city of Guayaquil.

## Balsa in Papua New Guinea, including East New Britain

Balsa has been cultivated successfully on a range of sites in PNG that offer good soils, high rainfall and an uninterrupted growing season. The primary area for commercial plantations in PNG is the Gazelle Peninsula in ENB. Although it has grown very well on sites in other provinces in PNG, much of this balsa cannot be marketed because there are no milling facilities in these areas, and export facilities and market access are limited. Furthermore, as balsa matures (for industrial uses) within 4–5 years of planting, it must be harvested or lose its marketability, and many of the trees in areas other than ENB are already too old for commercial harvest

## Box 1
## Alcan Baltek and the balsa industry

Alcan Baltek, part of the Alcan Composites Group within the larger Rio Tinto Alcan conglomerate, is the largest single corporate operator in the global balsa market; industry observers suggest that it controls 60–70% of the global market. Both directly and through a number of subsidiaries, such as Balmanta SA, Ecuatoriana de Balsa SA, Maseca and Plantabal SA, Alcan Baltek owns and manages balsa plantations in Ecuador and manufactures a wide range of balsa core products.

Baltek was founded in 1940 and the company has established its global dominance by offering innovative engineering solutions to the application of end-grain balsa sandwich composites. It joined the Alcan Corporation to become the Alcan Baltek Corporation in 2003. When Rio Tinto's Canadian subsidiary, Rio Tinto Canada Holding Inc., completed a friendly acquisition of Canadian company Alcan Inc. on 15 November 2007, Alcan Baltek became part of Rio Tinto Alcan Inc.

Alcan Baltek began large-scale plantation operations in the 1970s on land previously cleared for agriculture and now has 7,000 ha of balsa plantations spread over 28 sites in Ecuador. The plantation sites have high-quality soils and receive an annual average rainfall of 2,300 mm. The company has a tree improvement program and manages its own seed orchards.

The plantations are managed on 6–7 year rotations. At harvest, trees can be 27 m high and 46 cm in diameter. Trees are harvested and logs broken down in the field by a team using portable sawmills. Flitches are then taken to one of five larger processing mills where they are cut to size, knots and faults removed, dipped in fungicide to prevent blue stain and kiln-dried.

After kiln-drying, the balsa lumber is carefully graded into density classes and then glued into large end-grain blocks. These blocks are shipped to Alcan Baltek's plant in Northvale, New Jersey, United States of America (USA) where they are converted to end-grain sheet.

Baltek has been at the forefront of innovation in balsa utilisation since the 1930s when it developed balsa applications for structural cores and the hobby/model industry. During World War II, the balsa produced by the company successfully met the specifications of the aircraft industry. In the 1950s and 1960s, the company worked closely with the shipping industry to improve the use of balsa as insulation for sea-going liquefied natural gas (LNG) tankers. At this time, the company jointly developed the 463-L cargo system of the US Air Force, still widely used today: an aluminium-faced pallet, 274 cm × 224 cm (88 inches × 108 inches), with 5 cm (2 inch)-thick end-grain balsa as the core. Some 300 of these pallets, manufactured by the Army Air Force (AAF) Corporation, are imported annually for use by the Royal Australian Air Force.

Baltek developed the first scrim-backed flexible core. The emerging use of end-grain balsa in sandwich composites in marine hulls for yachts and other pleasure boats expanded the use of balsa core to include fishing vessels, commercial boats and military craft. Since the 1960s, the company has been at the forefront of expanding applications of end-grain balsa cores in sandwich technologies to include:

- pipes and processing tanks for the chemical industry
- food-processing tanks, industrial ducts and scrubbers
- water purification and desalination troughs and weirs
- blades for wind turbines
- commercial aircraft, rail cars, trucks and buses
- shipping containers
- bathtubs and shower stalls.

New products continue to be developed, including laminated products, specialist core-bonding adhesives and laminate bulker mats to serve improved sandwich technologies. More recently, hybrid cores using both balsa and polymer foams have been designed to enhance resin infusion.

Baltek Alcan has maintained its place as a leader in the world balsa sector and its continued innovation has contributed significantly to its corporate success over the past 70 years. More recently, its subsidiary, Plantabal SA, has recognised the need to demonstrate the sustainable management of its plantations and has begun the process of certification.

The Baltek range of products is marketed in Australia via ATL Composites, based on the Gold Coast, Queensland.

For reasons of corporate confidentiality, Alcan Baltek was unable to participate in this study.

Sources: Funding Universe 2000; Alcan Baltek 2009; this study

(Bourke and Harwood 2009). The main reasons for balsa's success in the Gazelle Peninsula appear to be a local interest in a broad suite of cash crops and proximity to processing facilities and a container port for quick and efficient export to world markets.

Balsa has become an accepted part of a group of cash crops that form the basis of the rural economy of the Gazelle Peninsula, where the production of cash crops and food crops has been skilfully integrated. The most important cash crops are oil palm (*Elaeis guineensis*), fresh vegetables, cocoa (*Theobroma cacao*), betel nut (*Areca catechu* or *A. macrocalyx*), copra (*Cocos nucifera*) and some Arabica coffee (*Coffea arabica*). The production of these export tree crops is dominated by smallholders and the crops provide incomes to about 80% of the population (Bourke and Harwood 2009). Balsa is regarded by all growers in ENB—smallholders and owners of larger plantation blocks—as a cash crop (interviews, this study).

## Cocoa pod borer

The cocoa pod borer (CPB), *Conopomorpha cramerella*, is a serious insect pest and has caused a severe reduction in cocoa production in ENB. It appeared in the Keravat area in early 2006 and since then has spread to other locations on the Gazelle Peninsula (Bourke and Harwood 2009). The production losses in infested areas are significant (20–50%) for smallholders who rely on the year-round cash income provided by cocoa, and the strict phytosanitary practices needed to address this problem have meant that large areas will become unproductive. There are some 55,000 ha of cocoa in ENB and it is estimated that some 30,000 ha will be withdrawn from production as a result of CPB (John Moxon, Lowland Agricultural Extension Station (LAES), Keravat, pers. comm.). The social consequences of this substantial community loss of income will be serious, having an impact on education, health, and law and order. There are community expectations that some of the former cocoa lands will be converted to balsa and that balsa cultivation might help minimise the effects of reduced cocoa revenues.

## Balsa's history in East New Britain

On the Gazelle Peninsula in 2001 there were more than 200 ha of smallholder balsa plantings and over 80 ha of private, company-owned balsa plantations. By 2003, the resource had grown to 700 ha and there are now about 3,500 ha planted, and this area is expected to reach 6,200 ha by 2012.

Balsa was introduced into ENB by the German Administration before 1914 and established at the Rabaul Botanic Gardens. Seed was made available to the general public from these introductions after 1938. The current location of progeny from these early introductions is unknown. Between 1947 and 1974, 10 further introductions were made, 9 of which were successfully established in trial plantings (Howcroft 2002). Early distinctions were made between *Ochroma lagopus* and *O. pyramidale*, but both are now considered to be the one species, *O. pyramidale* (CABI 2000). In 1961, a seed source imported as *O. lagopus* was introduced and established at Keravat. These introductions included batches from sites within the natural range of the species such as Colombia and Honduras (particularly the Lancetilla Botanic Gardens) and exotic sources such as Australia, India, Indonesia and Sri Lanka. The Indian and Sri Lankan sources were inferior, probably as a result of a narrow genetic base, and efforts were made to eradicate them. The Honduran source from the Lancetilla Botanic Gardens proved exceptional and trees of this provenance provided the base for tree improvement activities that began in 1980. The Indonesian sources are thought also to be contributing to the present gene pool, as are trees originating from the Colombian introduction (Doran 2009; Howcroft 2009).

In 1995, in response to a shortage of locally available seed, three batches of seed were collected and supplied by the National Tree Seed Centre from a seed stand at Oomsis, near Lae, Morobe province. These sources proved to be of very poor quality, producing trees with short boles and many branches, and are gradually being eradicated from the plantation estate.

In 1998–99, the PNG Forest Research Institute (PNGFRI) Lae imported seed from Honduras—10 seedlots from each of three provenances (Lancetilla Botanic Gardens, El Progreso and Lago de Yojoa), and these were planted in 2008 near the University of Natural Resources and Environment (UNRE) at Vudal and at LAES, National Agricultural Research Institute (NARI), at Keravat. Responsibility for the management and monitoring of these important plantings is unclear.

Balsa wood production and allied industry on the Gazelle Peninsula were severely disrupted by the volcanic eruption in 1994 which devastated the nearby port of Rabaul (Figure 9). Acidic volcanic ash defoliated many of the trees.

## The International Tropical Timber Organization Project

From 1996 to 2003, ITTO provided support over two stages to PNGFA to manage the ITTO East New Britain Balsa Industry Strengthening Project ('ITTO Project'). The project had several aims:

- increasing revenues to landowners by increasing the commercial volume production of a balsa crop over its rotation
- increasing volume production by breeding trees with desirable commercial characteristics such as straight stems
- increasing the plantation area by supplying seedlings of superior genetic stock
- providing a silvicultural manual and code of practice to ensure sustainable forest management.

The project offered high-quality extension services to growers, including supply of seedlings at a reasonable price and advice on site preparation, spacing, thinning and pruning. It provided important links across the supply chain, offering a forum for PNGFA, the growers and the industry to discuss issues and share information.

The project had a positive effect and the number of smallholder growers increased rapidly, establishing balsa on plots of 0.5–2.0 ha on their own lands. In addition, larger plantation owners (including some church groups) and processing companies began to establish their own plantations (Howcroft 2000, 2001, 2003; Howcroft and Ohana 2001).

The project recognised the need to offer high-quality germplasm to all growers and commenced a tree improvement program based upon selection of superior trees (candidate seed trees—CSTs; see Figure 5) and establishment of seed production areas, seedling seed orchards and conservation stands.

The main stakeholders in the industry worked with the project to produce an important draft 'code of conduct and practice' (Anon. 2000) for the industry. *The balsa manual* (Howcroft 2002) was produced to provide information on growing balsa, and contained a valuable set of log volume tables that remains in use.

Importantly, the ITTO Project provided an opportunity to monitor progress with the balsa industry, identify key stakeholders and offer targeted responses. Unfortunately, since 2003, many of the services put in place by the project have declined, although PNGFA still provides balsa seedlings to smallholders at competitive rates and maintains a level of contact with the industry through dispersal of stumpage cheques to growers. It is able to offer a service to industry through providing statistics on exports via the records derived through the export permit system.

Despite the success of this early and timely project, most balsa growers and processors in ENB now receive little extension support from government or other sources.

## Balsa silviculture in East New Britain

Various aspects of balsa silviculture in ENB are shown in Figure 10. *The balsa manual* (Howcroft 2002) and the former extension services of the ITTO Project provided some excellent foundations for silviculture and plantation management of balsa. Most growers now adopt their own variations of silviculture, many of which are influenced by the availability of funds and labour. Baynes (2002) summarised balsa silviculture in ENB.

**Figure 9.** Rabaul Harbour, from which balsa produced in East New Britain is shipped, as it appeared in 2009 (Photo: Stephen Midgley)

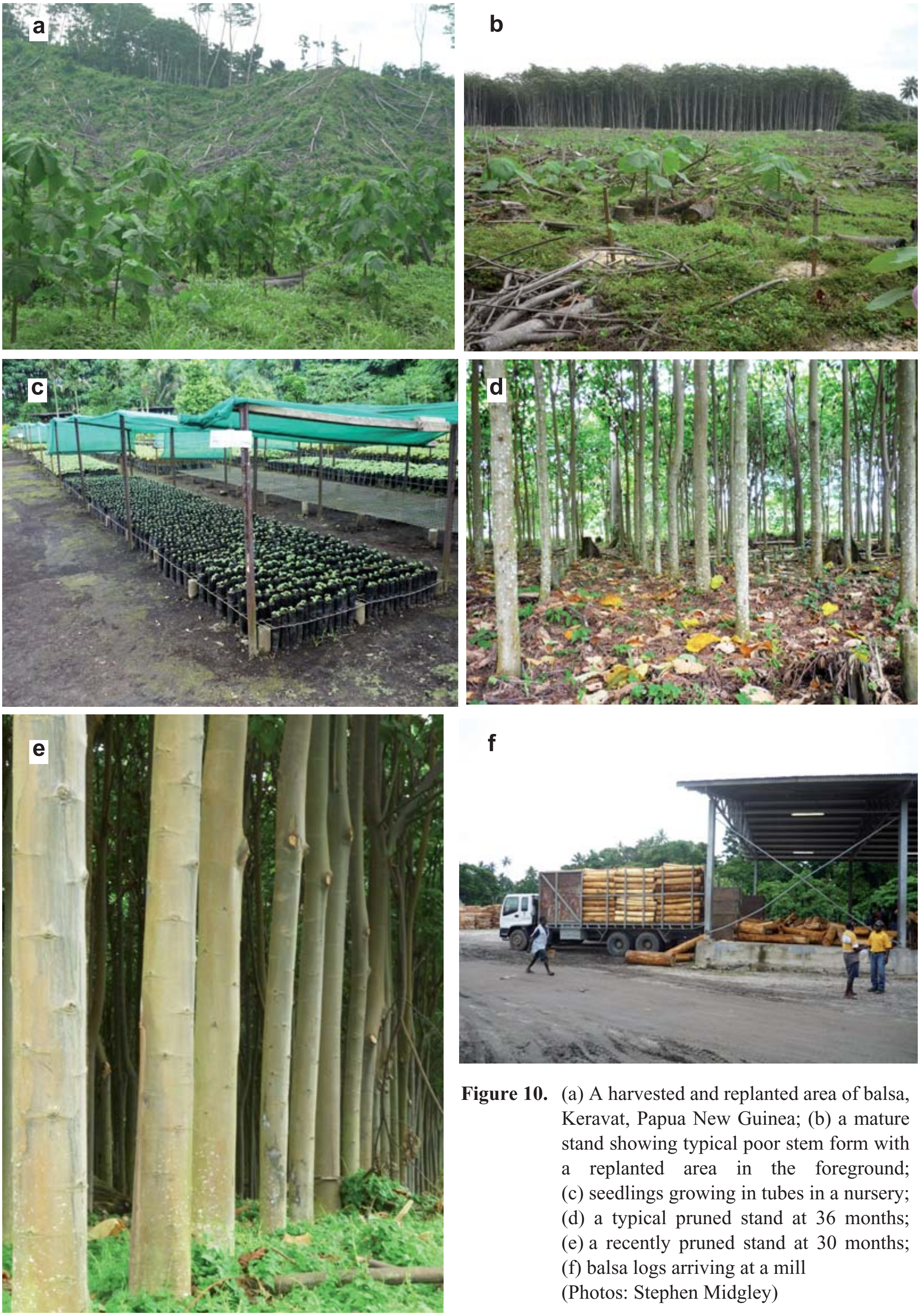


**Figure 10.** (a) A harvested and replanted area of balsa, Keravat, Papua New Guinea; (b) a mature stand showing typical poor stem form with a replanted area in the foreground; (c) seedlings growing in tubes in a nursery; (d) a typical pruned stand at 36 months; (e) a recently pruned stand at 30 months; (f) balsa logs arriving at a mill
(Photos: Stephen Midgley)

*Site preparation and seedling establishment*

As a pioneer species, balsa grows well in full sunlight and therefore the site must be cleared of bushes etc. before planting. Planting out of the seedlings is usually done in most months after rain, and survival is generally high, with few growers reporting a need to refill after planting. Mortality through drought is low as ENB receives high and uniform rainfall, the soils are fertile and well-drained, and light and temperature conditions favour plant growth.

Application of mineral fertiliser is uncommon, although fertilisers are recommended on sites where repeated cropping has led to a decline in fertility, or sites that are dominated by aggressive grasses such as guinea grass (*Panicum maximum*) or blady grass (*Imperata cylindrica*), where nitrogen deficiency may be present. Limited boron may detract from tree performance (N. Howcroft, pers. obs.). None of the growers interviewed for this study applied fertiliser. One grower interviewed mentioned lack of vigour in a third-rotation crop that may respond to fertiliser. Howcroft (2002) cites examples where balsa has been grown in several rotations over 15 years on the same site without evidence of yield decline in successive generations. However, he suggested that given balsa's fast growth and production of strong and active surface roots, 'it is expected that at some point in time the soil fertility will reduce and that fallowing and fertilisers must be used' (Howcroft 2002).

Almost all weeding is done by hand slashing; few growers use herbicides to control weeds, for reasons of cost and fear of damaging the balsa seedlings. As crown closure takes place after the first several months, the only crops that can be grown in association with balsa are quick-growing ones such as peanuts.

*Spacing*

There are many prevailing views about initial tree spacing for balsa and there is no accepted norm in ENB. Growers consider a number of factors:

- the need to complete crown closure as early as possible to minimise weeding expenses
- the need to improve tree form and produce a long log length before the first node by planting at close spacings, such as 2.1 m
- processor preference for logs with diameters of 35–45 cm at 5 years of age
- a demonstrated unwillingness by many growers to thin the weaker stems (if planted at close spacings) at an early age, i.e. 16 months.

Many growers have adopted a spacing of 3.0 m × 3.0 m, providing an initial stocking of 1,100 trees/ha, rather than 2,200 trees/ha with spacing at 2.1 m as practised earlier. A compromise spacing is 2.5 m. Landowners tend to plant in a triangular pattern rather than a square or rectangular pattern and this alters the initial stocking slightly.

*Pruning*

Trees are not usually pruned, but any trees showing the characteristics of the Oomsis strain—that is, persistent low branching—are either thinned out or pruned. In PNG, growers observe three types of tree: those with small, weak branches that self-prune readily; those with persistent branches that sag or bend with age and die; and those with branches that persist. The last type of tree is pruned at age 9–12 months. If growers seek a longer log from the second internode, it is common to remove all but one of the branches at the top of the first internode—a process known as 'jorqueting'; a term borrowed from the cocoa sector.

*Thinning*

For trees planted at a spacing of 3.0 m (1,100 trees/ha), a first thinning is recommended at age 3 years to a stocking of 450–550 trees/ha. This is followed by clear felling at age 5 years.Thinning is recommended—although not always completed—and thinning schedules depend on initial tree stocking. For trees planted 2.5 m apart, giving a stocking of 1,600 trees/ha, thinning to waste to a stocking of 1,260 trees/ha is recommended at 18 months. This is followed by a commercial thinning to a stocking of 630 trees/ha at age 3.5 years, with clear felling at age 5–6 years.

The main issue is that growers seeking to obtain early returns from early thinning of their balsa crop remove the larger trees for sale—that is, they thin 'from above'. This has serious consequences for the plantation. Thinning should be 'from below', removing weaker trees according to the criteria of vigour, form and spacing, and allowing better-formed trees to develop to provide superior logs (and ultimately higher returns). Some growers are now considering a thinning schedule entailing the systematic removal of every third row, but this approach still removes 30% of the best trees.

*Rotations*

After felling, some blocks have been allowed to re-establish as natural regeneration, but the resulting stands can be very dense—up to 25,000 trees/ha. Growers are encouraged to thin these stands to a spacing of 3.0 m × 3.0 m before the age of 15 months.

The rotation for balsa in ENB varies from 4 to 6 years depending on site quality, tree size and the grower's need for a financial return. The norm appears to be 5 years and the maximum recommended rotation is 6 years. While the trees are still growing quickly at this age, experience has shown that after this time they begin to form heartwood and suffer from internal degradation. Wood affected with red heart is unacceptable to the processors. Processors prefer logs that are >35 cm in diameter as these offer greater recovery of sawn material, and growers are encouraged to harvest their trees at age 5 years.

*Pest management*

Several insect and fungal pests have been recorded on balsa in ENB, although none has offered a threat to the industry so far. There have been suggestions that the incidence of disease and problems with insect pests may increase if balsa expands onto land previously used for cocoa. Howcroft (2002) observed that the incidence of insect problems was higher on sites close to old cocoa blocks or land previously planted with cocoa. Furthermore, balsa is susceptible to some of the root diseases that are found in cocoa. Good harvesting practices are recommended to reduce the incidence of disease, including leaving very short stumps to minimise inoculum for root-rotting fungi and breeding grounds for wood-boring insects such as longicorn beetles.

## Tree improvement and supply of high-quality seed

The ITTO Project made an excellent start to balsa tree improvement, but since the conclusion of the project there has been no clear responsibility for maintenance of the assets of candidate seed trees (CSTs) and seed orchards and many of these valuable resources have been lost. Doran (2009) estimated some 70–80 CSTs are currently available and under the control of the PNGFA Forestry Office at Keravat. The capacity of PNGFA to supply high-quality seed is limited and growers typically find their own sources of seed.

In response to this unfortunate state of affairs, the Secretariat of the Pacific Community (SPC) Facilitating Agricultural Commodity Trade (FACT) Project is now working with PNG Balsa to develop a balsa improvement and germplasm supply breeding strategy. One of the early recommendations from this work is that a cooperative breeding program be established to include all major growers and appropriate government agencies (Doran 2009).

## Balsa growers in East New Britain

Balsa is not grown on government lands and is normally grown on lands with private title. The balsa growers of ENB represent a broad cross-section of the community. They include large plantation owners, groups of owners who have plantation assets, various churches, influential leaders in the community, smallholders and processors. In 2003, when it was estimated that the total balsa planted resource was 700 ha, there were an estimated 400 smallholders with plots of <5 ha growing some 80% of the resource. The remaining 20% was controlled by groups of landowners pooling plantation assets, by processors and by some leaders in the community. By 2012, when the balsa plantations are expected to grow to 6,200 ha, the balsa-growing community will be dominated by plantation blocks larger than 20 ha, with only 300 ha (5%) controlled by smallholders with plots of <5 ha. With the exception of about 1,400 ha of plantations controlled by large freehold owners, most larger plantations are leased from, or managed by, groups of landowners who have pooled their plantation resources. This change in resource management has been brought about by the need for processors to become more proactive in interacting with growers to ensure regular and reliable supply to their mills. Unlike other tree species, which can be left growing at the end of a nominal rotation if markets are poor, balsa must be harvested by the age of 6 years or the wood deteriorates. It has proven difficult for smallholders to accommodate the fluctuating demand for balsa logs, and this has discouraged several growers from replanting and remaining part of the industry. Among the benefits from consolidated plantings are the options to apply improved and timely silviculture and to reduce harvesting costs.

## Balsa yields and inventory

Conservative yields from regular plantations are reported to be 200 $m^3$/ha at year 5, while yields from poorly managed plantations can be as low as 180 $m^3$/ha. Yields from plantations on good sites and managed by skilled growers have regularly exceeded 400 $m^3$/ha at year 5. Some yields from experimental plantings have exceeded 500 $m^3$/ha (Howcroft 2002).

Little attention has been paid to detailed inventory of balsa plantings in ENB—nearly all figures for areas and volumes are estimates only. There are no permanent sample plots as would be expected in commercial plantations of other timber species. This situation is changing as the resource becomes dominated by larger blocks of trees and as processors recognise the need to better manage the resource base if they are to meet expectations of reliable supply to global markets. Influencing this change is the current resource scarcity; the balsa supply in ENB is tight at present and will remain so until 2012. This has encouraged processors to locate growers and delineate and record blocks of balsa using global positioning system (GPS) and geographic information system (GIS) devices.

## Harvesting and hauling balsa

Almost all balsa is harvested and delivered to the mill door by processors using their own equipment and logging teams. Chainsaws are used to fell trees; standards in directional falling appear to be low and considerable damage to the logs has been reported when logs are felled across already-fallen timber. Most balsa growers sell their resource at the stump to a local processor who arranges for harvesting and transport the mill. The processors purchase balsa logs at a negotiated stumpage rate (per cubic metre) and growers are keen to ensure that the maximum volume of merchantable logs is recovered. Stumpages are influenced by distance from the mill, quality of the resource, quantity available, maturity of resource (size) and accessibility (terrain and distance from the road). These factors are discussed later in this report ('The dynamics of balsa purchase').

Logs are cut into billets of varying length—some processors prefer 2.2 m and others 1.8 m. Most will take billets down to a minimum length of 1.1 m. While processors prefer logs of 35 cm in diameter, they accept logs to a minimum end diameter of 17 cm. Trucks of varying capacity (3 and 15 t trucks were noted) are loaded by hand. Very little mechanised equipment (such as the specialised logging gear used in the broader forestry sector) is used for balsa harvesting with the exception of some small farm tractors. The deteriorating quality of roads on the Gazelle Peninsula was obvious during this study and contributes to rising vehicle maintenance and haulage costs.

A major concern expressed by growers was a perception of excessive waste during harvesting. Reports are common of marketable logs being left inexplicably in the field. Some growers engaged their own labourers to ensure that all merchantable logs were removed from the site. Among the reasons provided by processors were that discarded logs did not meet specifications (see, for example, Appendix 1, 'Papua New Guinea balsa log grading rules'), particularly those relating to branches, red heart, branch stubs, minimum diameter and length. Harvesting teams lacked appropriate equipment to efficiently recover any logs felled into steep gullies.

## Transport costs

The variation in prices received by growers relative to distance from the mill is illustrated in Figure 11. The data on which this relationship is based were collected from a sample of growers in ENB in July 2009. Growers and processors advised that while distance is a key factor in establishing price, quality, access, scale and maturity are also important. Processors who provide harvesting and transport services to growers indicated that the maximum distance that they would haul logs was around 40–50 km. Figure 11 indicates that resources grown within 10–15 km of a processing mill attract almost twice the stumpage rate of resources grown 50 km from a mill.

The more distant growers would have to supply large volumes of consistently high-quality balsa to offset some of the price differential associated with their location. Alternatively, balsa plantation growers located more than 45 km from a mill may find it profitable to process their logs into flitches at the point of production and then transport the sawn wood to processors for drying and further processing. Growers may also benefit from drying the flitches before shipping them for downstream processing, although this is technically challenging for individual growers. The feasibility of these supply options—including implications for quality of the sawn wood from portable sawmills and chainsaw mills—should be explored further.

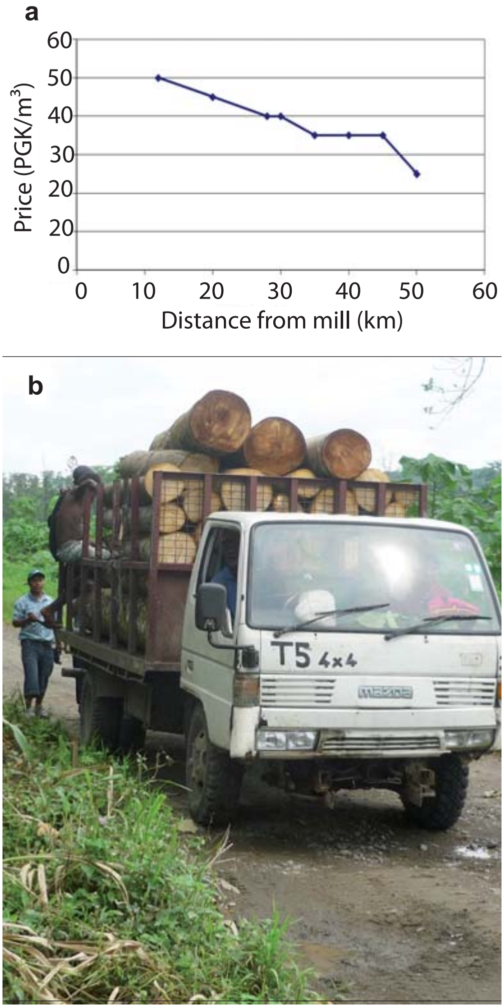


**Figure 11.** (a) Variation in prices received by growers with distance from the mill (Source: Survey data, July 2009); (b) relatively small trucks are used to haul balsa in Papua New Guinea, carrying 6–24 m$^3$ per load (Photo: Stephen Midgley)

## Processing balsa

Various aspects of processing balsa are shown in Figure 12. Three mills were operating on the Gazelle Peninsula in 2001, and these processed balsa purchased from both smallholder and commercial plantation producers. By 2007, there were 4 mills in ENB, and this number increased to 11 in 2009. Some process balsa wood and export a variety of balsa products to international markets, while others saw logs and prepare rough-sawn, air-dried flitches (commonly 1.8 m × 100 mm × 100 mm) for sale to the exporting processors. Processing facilities vary in volume and sophistication and are designed to meet various market segments. Some mills are simply a single circular breakdown saw, while others follow the process through to advanced balsa products. Larger mills aiming to improve efficiencies and recoveries use twin-bladed breakdown saws that help to prevent splitting and warping due to growth stresses.

Logs are sawn within a day of reaching the sawmill; delays in sawing are not encouraged due to the risks of blue stain and splitting—some logs begin to split as soon as growth stresses are released. Growth stresses are an issue for sawing, as is sawing around the pith, which is not always centrally located in the log.

All export-oriented processors kiln-dry green-sawn flitches before sizing, finishing and sanding, and preparing glued blocks or panels. Moisture content is taken down to 10% with a preferred moisture content of 12% as product leaves the factory. Kilns are mostly wood-fired with residues, and vary in capacity and efficiency.

Sawmilling recovery is dependent on billet quality and size. Primary recovery after initial sawing to green, rough-sawn flitches is less than 50%. Depending on the final size and quality of the product, recovery after sawing, kiln-drying, planing and sanding can vary: from 17% to 25% for glued blocks; from 12% to 18% for end-grain sheets; to 18% for blocks; and to as low as 7% for 1 mm balsa sheets.

Most export-oriented processors serve particular niches within the global markets and have their own particular standards. For example, first-grade balsa, suitable for hobby use, must be absolutely clear of knots and defects and is a uniform white colour. The industrial balsa wood market allows some colour and defects in the wood but insists on uniformity and may specify particular density classes. Not all processors have access to all market niches.

The ENB mills could conceivably cater for balsa produced in other parts of PNG. However, in order to be economic, the balsa would have to be processed into flitches before being shipped to ENB for final processing, which means that flitch-processing plants would have to be established in the other balsa-growing areas. The realities of quality control and controlling mill-door delivered costs, and the unreliable nature of shipping and a deteriorating road system, suggest that the feasibility of shipping flitches to Rabaul for further processing will need careful analysis.

## Balsa processors in East New Britain

The 11 processors of balsa currently operating in ENB (Nicholas Mitar, PNGFA, pers. comm.) vary in capacity and sophistication. Some focus on export

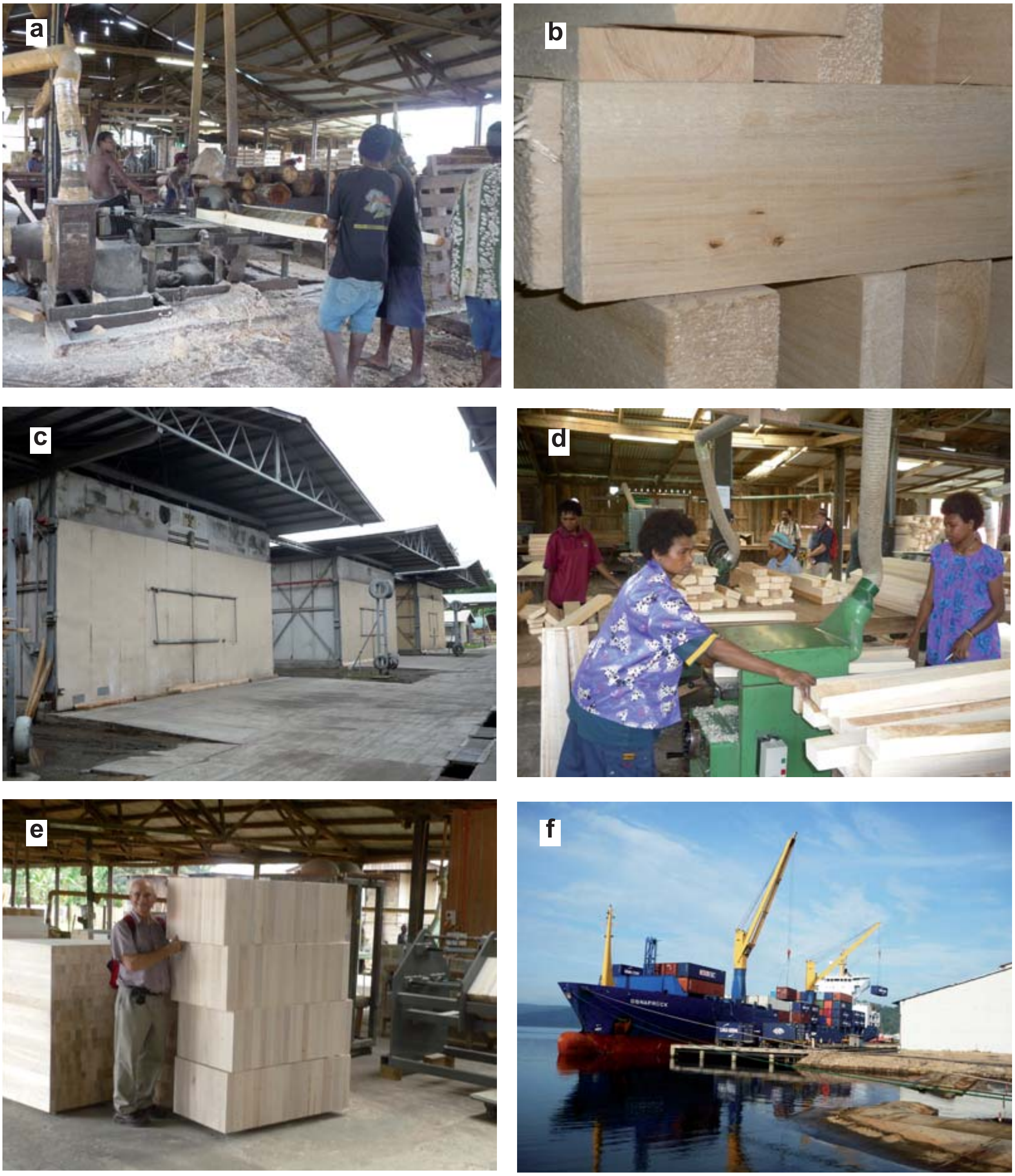


**Figure 12.** (a) A small balsa sawmill; (b) sawn kiln-dried flitches; (c) large drying kilns; (d) planing dried blocks; (e) large glued blocks ready for dispatch; (f) loading a ship in Rabaul Harbour (Photos: Stephen Midgley)

markets and others focus on supply of green, rough-sawn flitches to the export processors. The larger processors are moving towards integrated supply and processing systems where the processor can exert a larger influence over costs and supply. This is a consequence of the current undersupply of raw material. The processors include the companies outlined below.

*The PNG Balsa Company*

The PNG Balsa Company plants, harvests and processes balsa at primary and secondary levels and produces downstream products for export. A professional plantation team manages its field facilities of nurseries and plantation infrastructure and its facilities include mechanical and saw-doctor workshops, a primary processing mill, drying kilns, secondary

**Table 3.** Factors contributing to successful development of balsa plantations in East New Britain

| Factor | Strengths | Challenges |
|---|---|---|
| Infrastructure development | Extensive network of sealed roads linking growers, processors and port<br>Deep-water port with direct shipments to export markets<br>Balsa-processing operations located close to plantations | Port capacity and efficiency as balsa production increases<br>Availability of suitable labour for balsa processing<br>Institutional arrangements governing balsa exports |
| Financial competitiveness | Short-rotation tree crop generating positive cash flows after 5 years<br>Long production history<br>Seedlings provided by Papua New Guinea (PNG) Forest Authority at cost | Managing plantation as a renewable tree crop and not as a resource<br>Continuity and consistency of supply from smallholders over multiple rotations<br>Relative returns to labour |
| Access to technology | International Tropical Timber Organization (ITTO) East New Britain Balsa Industry Strengthening Project 1996–2003 provided high-quality extension services, seedlings and professional advice on silvicultural practices<br>*The balsa manual* (Howcroft 2002) | Since completion of ITTO Project, technical support has declined significantly<br>PNG Forest Authority extension services |
| Threat of loss | Relatively stable provincial economy and society with good cash incomes, high land potential and very good access to services (Hanson et al. 2001)<br>Established infrastructure<br>Competitive industry structure | Volcanic eruptions<br>Disruption to the local economy due to cocoa pod borer and associated loss of livelihood for many smallholders<br>High population density |
| Expediency | Tolai people of East New Britain are well educated and have a long history of trade and commerce (Newlin 2000)<br>Perennial tree species have been grown as part of land-use systems for generations | Awareness and understanding of market vagaries and benefits of good silvicultural practices<br>Understanding operations and costs along the balsa supply chain<br>Need for short-term income |
| Inexperience | Long history of growing perennial tree crops including coconut palms for copra, cocoa, coffee<br>ITTO Project<br>Short-rotation tree crop | Possible new supply arrangements for smallholders |
| Security of tenure | Established land groups<br>Opportunity for smallholders to grow trees and sell resources to processors<br>Private ownership of larger estates | Competition for land withdrawn from cocoa production |

manufacturing infrastructure and warehouses. PNG Balsa is the largest balsa processor in PNG with an annual processing capacity of 90,000 $m^3$ of logs and the company has made a substantial commitment to international marketing and maintaining the competitiveness of balsa products from ENB. The company purchases balsa from many growers and has established over 2,000 ha of its own plantations under joint-venture and share-farming agreements with landowners; this plantation estate will increase to 4,000 ha by 2012 and the company has the capacity to process all plantation production to export standards for blocks, sheets, glued blocks and fibreglass-backed, end-grain sheets. PNG Balsa recognises the benefits to be gained through use of best-quality germplasm and has begun a tree improvement program in collaboration with the SPC's FACT Project.

*GSMC/Auszac Balsa Alliance*

The GSMC/Auszac Balsa Alliance is based on GSMC, the longest-standing balsa processor in PNG. Its long-term focus has been the demanding international model markets; this has been broadened to include kiln-dried, glued blocks for Chinese markets. Traditionally, the company has purchased logs directly from growers and is now working to complement this supply with product from its own plantations of 135 ha. The mill's installed capacity of 5,000 $m^3$ logs annually is being increased by 50%.

*Gunter Balsa Limited*

Gunter Balsa Ltd is the most recent processor to begin production and is linked directly to balsa distributors and manufacturers in Germany via its parent company. The company has no dedicated plantation base and has a supply strategy based on small growers. Although it has just started production, the modern sawmill, kilns and finishing facility have a potential annual processing capacity of 14,000 $m^3$ logs. The company has developed a strong relationship with the University of Natural Resources and Environment where it offers information support and experience to students.

*Coconut Products Limited*

Coconut Products Limited (CPL) is the largest private landholder in ENB, with major interests in coconut, cocoa, cattle and aquaculture, and the company plans to build its balsa plantation estate to 1,200 ha. It currently operates a small, primary-breakdown mill and produces green, rough-sawn flitches for other processors who dry and convert the blocks to kiln-dried, glued blocks. The company has plans to establish its own processing facilities which will produce export-standard products. Like PNG Balsa, CPL has recognised the need for high-quality germplasm and has maintained a basic selection and genetic improvement capacity.

Other processors include Takubar Centre Limited, Avenell Engineering, Tavilo Timbers Limited, North Baining Timbers and Niugini Models (PNG) Limited.

## The success of balsa in East New Britain

The successful development of the balsa industry in ENB has been underpinned by several strengths, as illustrated in Table 3. While these strengths support a vibrant industry, the industry must face a number of challenges in order to sustain its success in the future.

# Trade and balsa markets

## Tariff codes

International trade data on balsa and balsa products are challenging to locate. Balsa is classified in a category combined with other woods (virola, mahogany, imbuia and balsa) rather than having a specific code at the international Harmonized System Codes of the World Customs Organization (HS) 6-digit level. Some countries have more detailed information at the national tariff line level, including the USA, and this has been used to create Appendix 2, a summary of US balsa imports.

An added complication is that the main HS code that includes balsa ('HS 440724 Wood of virola, mahogany, imbuia and balsa, sawn or chipped, sliced or peeled, exceeding 6 mm in thickness') was changed to a new category excluding mahogany from 2007: 'HS 440722 Wood of virola, imbuia and balsa, sawn or chipped, sliced or peeled, exceeding 6 mm in thickness'. Since 2007, Ecuadorean official statistics for exports are described under the Product Number 4407220000 (that includes balsa, virola and imbuia woods) of the Andean Trade Community Standard Product Code System known as NANDINA. The potential for a mix of species in this product number must cloud any statistics of balsa from Ecuador based on it, although this study was informed that 'balsa is the driver in the product number' (Austrade 2009).

Balsa enjoys an import status in the USA sufficient to warrant its own codes. In a review of the US market for tropical timber products, Goetzl and Ekström (2007) provided tables containing all codes that make up the standard commodity groupings as defined by the United States Department of Agriculture (USDA) Foreign Agricultural Service (FAS) and which appear in the standard 2- and 5-year reports. The commodity codes were derived from the Harmonized Tariff Schedule (HTS—this schedule has been devised for imports; the HS schedule for exports) to the 6-digit level for generalised categories. The USA defines products using 10-digit HTS codes. Exports codes (which the USA calls Schedule B) are administered by the US Census Bureau. Import codes are administered by the US International Trade Commission (USITC). The relevant codes identified by Goetzl and Ekström (2007) for balsa were:

- 4407220006 HW [hardwood] lumber balsa. Balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm
- 4407230005 HW lumber balsa. Balsa wood sawn lengthwise over 6 mm, rough
- 4407230010 HW lumber balsa. Balsa wood sawn lengthwise, over 6 mm, NESOI[5]
- 4407240005 HW lumber balsa. Balsa, rough, tropical, wood sawn or chipped lengthwise, sliced or peeled
- 4407240006 HW lumber balsa. Balsa wood, sawn/chipped lengthwise, GT 6 mm thick
- 4407240010 HW lumber balsa. Balsa, not rough, tropical wood sawn or chipped lengthwise, sliced or peeled.

An independent search of the USDA FAS website reveals that the USA appears to have had three HTS codes for balsa products until 2007:

- 440724005 Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness over 6 mm, rough
- 440724006 Balsa wood, sawn/chipped lengthwise, greater than 6 mm thick
- 440724010 Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm, NESOI.

These appear to have been combined into a single category in 2007:

- 4407220006 HW lumber balsa. No. cubic metres balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm.

[5] NESOI = not elsewhere specified or included

While the HTS codes can offer some clarity for the US market, balsa appears to remain combined with other tropical woods in other reporting regimes (including Europe, China and Australia under 'HS 440722 Wood of virola, imbuia and balsa').

## Exports from Papua New Guinea

Fortunately, PNGFA, through its export permit system, maintains credible records of all balsa exports, and reliable export histories are available. Balsa exports from PNG generated an average of PNG kina (PGK) 6 million per annum from 2004 to 2006, which was about 1% of the value of forest product exports in this period. The value increased to PGK11.2 million (US$4.2 million) in 2008 as total volume exported grew to 12,700 $m^3$ (Figure 13). This represents some 8% by volume and 6% by value of the global market.

Until 2003, balsa was exported to Australia, China, Germany, Italy and the United Kingdom, but since then a greater proportion has gone to China and India. In 2008, the main export destinations were China (43%), India (32%), USA (11%) and Australia (6%) (Figure 14). This changing global market indicates the need for proactive and efficient marketing programs.

It is expected that balsa exports from Rabaul will continue to expand. The processing community is confident and believes they have secured reliable future markets. By 2012, when the balsa estate is expected to reach 6,200 ha, the industry will be harvesting 1,240 ha annually which, at a conservative 200 $m^3$ log harvest per hectare and a 23% average product recovery, suggests that exports will grow to 57,000 $m^3$. Assuming a conservative average price of US$403/$m^3$, the export balsa trade will grow to US$23 million annually.

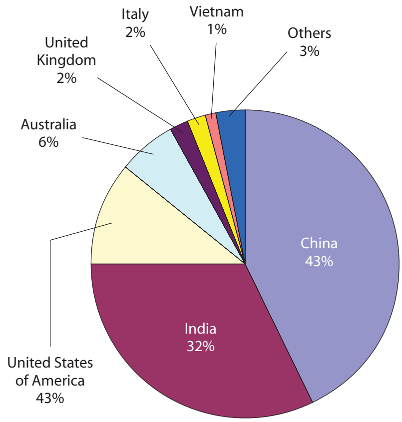


**Figure 14.** Destination of balsa exports from Papua New Guinea by volume, 2008 (Source: PNG Forest Authority)

## Exports from Ecuador

Fletcher (1949) noted that Ecuador provided 95% of global production in 1943, and UNCTAD (2001) reported that Ecuador satisfied 80% of the world demand for balsa in 2001. Ecuador remains the

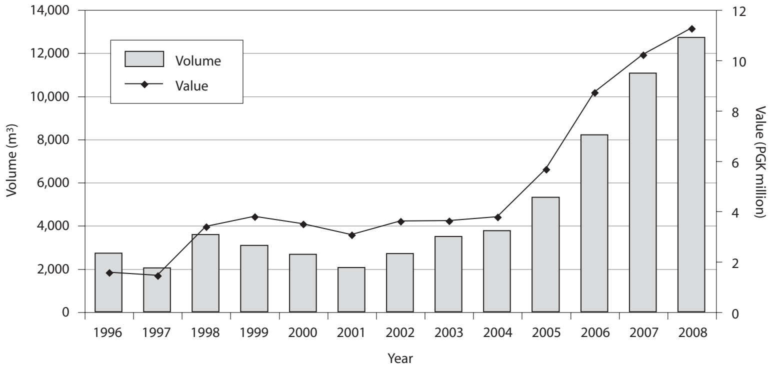


**Figure 13.** Historical volumes and values of Papua New Guinea's balsa exports 1996–2008 (Sources: 1996–2002, International Tropical Timber Organization (ITTO) East New Britain Balsa Industry Strengthening Project Phase 2; 2003–2008, PNG Forest Authority)

world's dominant supplier of balsa. Reliable statistics for Ecuador's balsa industry are notoriously difficult to find as the industry appears to maintain a culture of considerable secrecy.

Using statistics obtained from four different official sources including the Ecuador Central Bank, the Ecuadorean Exports Promotion Agency (CORPEI) and the Latin American Integration Association (ALADI), this study estimates that in 2008 Ecuador exported around 137,956 $m^3$ of balsa (20,000 t at an assumed average density of 130 $kg/m^3$) valued at US$61.3–70.3 million free on board (FOB) (Austrade 2009). In 2008, industry sources reported that an average of 200 40-foot containers (FEUs) were exported from Ecuador each month. Assuming that an FEU can hold 45–54 $m^3$ of balsa product (volumes vary depending on packaging and whether or not the material is stacked on pallets), this figure suggests that 108,000–130,000 $m^3$ of balsa were shipped from Ecuador in 2008. Using a notional average figure for FOB prices of US$403/$m^3$ (see Table 4), Ecuador's exports of balsa were worth about US$43.5–52.4 in 2008, differing somewhat from the export total cited by the Ecuador Central Bank of US$65 million (Table 5).

**Table 4.** Free-on-board (FOB) prices, dimensional lumber, Ecuador: balsa exports to the USA (Source: International Tropical Timber Organization (ITTO) Market Information Service (MIS) Reports 2005–2007)

| Date | Price (US$/$m^3$) |
|---|---|
| Oct 2005 | 403 |
| Nov 2005 | 461 |
| Dec 2005 | 421 |
| Jan 2006 | 387 |
| Feb 2006 | 393 |
| Mar 2006 | 413 |
| Apr 2006 | 429 |
| May 2006 | 405 |
| Jun 2006 | 386 |
| Sep 2006 | 403 |
| Oct 2006 | 403 |
| Feb 2007 | 403[a] |

[a] From February to September 2007, the price remained constant at US$403/$m^3$

Pastor (2004) and Vásquez (2005) offer figures for exports from 1999 to 2003 that indicate that the total volume exported from Ecuador was stable over that period (Table 6).

The dominant market for balsa from Ecuador is the USA which formerly absorbed over 90% of exports. Vásquez (2005) reported that, between 1999 and 2003, the USA imported some 98% of Ecuador's balsa exports. While remaining the single largest export destination, the USA is not as dominant now, and NANDINA statistics for Product Number 4407220000 (where balsa is the main driver) suggest it now absorbs 40–45% of all balsa exports; the NANDINA data demonstrate that China and European markets in Spain, Denmark, Germany and France are now importing more balsa (Figure 15). Assumptions in Table 5 include that 90% of Ecuador's exports under NANDINA Product Number 4407220000 are balsa and that the average density of all balsa exported is 130 $kg/m^3$.

**Table 5.** Ecuador's balsa exports 2008 (Source: Ecuador Central Bank)

| Country | Volume ($m^3$)<br>*Value (FOB[a] US$ '000)* |
|---|---|
| United States of America | 61,338<br>*26,574* |
| Denmark | 15,092<br>*8,199* |
| Spain | 14,850<br>*7,940* |
| China | 12,067<br>*5,040* |
| Germany | 8,578<br>*4,959* |
| France | 6,473<br>*3,873* |
| Brazil | 6,764<br>*3,818* |
| United Kingdom | 2,465<br>*930* |
| Australia | 2,631<br>*733* |
| United Arab Emirates | 1,613<br>*829* |
| Others | 6,085<br>*2,033* |
| Total | 137,956<br>*64,928* |

[a] FOB = free on board

These figures, especially those for the USA, which indicate 2008 imports of 61,338 $m^3$ valued at US$26.57 million, are at odds with the import data offered by the official US Trade Statistics (Appendix 2), which indicate imports of balsa of 73,611 $m^3$ in 2008, valued at US$34.96 million.

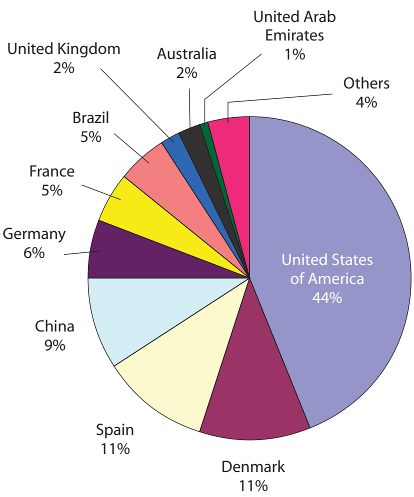


**Figure 15.** Destinations of balsa exports from Ecuador by volume, 2008 (Source: Ecuador Central Bank)

Through combining modified figures from Pastor (2004) and Vásquez (2005) and the US Trade Statistics (Appendix 2), Figure 16 indicates that the volumes of US imports of balsa have been fairly stable from 1999 to 2008. However, the annual value of these imports has increased from US$20 million to US$35 million over the same period. This may be the result of more sophisticated processing and greater value-adding in Ecuador. For example, more Ecuadorian processors now export end-grain balsa sheets rather than glued blocks. A concern expressed by the balsa processors interviewed during this study was that the expansion in plantations in response to market shortages in 2006–2007 has greatly exceeded the expansion in markets and that a lot of work would be required to market balsa that would be available after 2013.

ITTO has offered regular updates on FOB prices for dimensional lumber of balsa (Table 4). It is not clear if these are derived as a function of total declared volumes and values or if they represent actual FOB values for dimensioned balsa blocks. Based on market prices obtained during this study, it is likely that these prices represent kiln-dried balsa blocks.

The global economic crisis has had an impact upon Ecuador's exports of balsa, with some industry observers suggesting that 2009 sales to Europe alone had decreased by 35–45% over the same period in 2008.

**Table 6.** Ecuador's total exports of balsa 1999–2003

| Source and attribute | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|
| Vásquez (2005) (US$ '000) | 18,598 | 14,977 | 16,470 | 18,036 | 20,614 |
| Pastor (2004) ($m^3$) | 77,155 | 76,284 | 75,686 | 70,837 | 68,802 |
| Pastor (2004) (US$ '000) | 19,636 | 15,148 | 17,100 | 18,499 | 19,491 |
| Pastor average price (US$/$m^3$) | 256 | 198 | 225 | 261 | 283 |

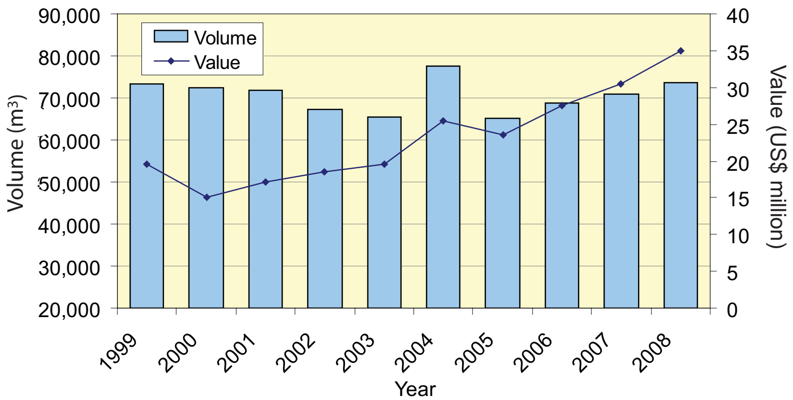


**Figure 16.** Volume ($m^3$) and value (US$) of balsa exports from Ecuador to the United States of America, 1999–2008

## The global market for balsa

There are challenges in locating accurate figures for trade in balsa, including the lack of a balsa-related tariff code (see above). In 2008, however, the total global market for basic balsa products was estimated to be 155,000 $m^3$. This includes the figures for both PNG (12,700 $m^3$) and Ecuador (138,000 $m^3$) and a nominal estimate of 5,000 $m^3$ for combined 2008 exports from Colombia, Brazil, Venezuela, Costa Rica and Indonesia. Using the assumptions discussed above, and allowing for ITTO's average FOB value of US$403/$m^3$ for exports from the minor producers, the global market for balsa was worth about US$71 million in 2008.

Ecuador is obviously the world's dominant supplier of balsa and with its large, well-established plantation resource of more than 18,000 ha will remain at the forefront of global supply. There has been a substantial but unquantified recent expansion of the Ecuador plantation resource. Unconfirmed reports suggest plantation expansion in Brazil and several other countries has the potential to increase the supply of balsa. Ecuador's recent history of political and economic instability might encourage manufacturers to seek alternative, reliable and stable sources of balsa. In promoting the use of synthetic foams for wind-energy applications, it was recently observed that 'political instability has concerned some major users of balsa' (PolymerOhio 2009).

The USA remains the world's dominant client and US imports of balsa have remained generally constant at about 70,000 $m^3$ annually for the past 10 years, However, as a proportion of global trade, these imports have fallen from over 80% of the value of global trade in 2001 (UNCTAD 2001) to an estimated 51% in 2008. This change is probably due to industries in Europe, China and India expanding imports to provide balsa cores for sandwich composite applications for wind energy and air, rail and road transport. Data for balsa imports to Europe, China and India are confused by the lack of specific tariff codes, but industries that use balsa such as those in the wind energy and the defence manufacturing sectors are expanding in all three regions.

The mix of balsa products being exported from Ecuador and PNG is also changing. As the skills and sophistication of processors in these countries grow, more balsa is being sold as end-grain panels. Markets such as India and China, however, have a preference for glued blocks as these enable them to complete value-adding in those countries at lower processing costs.

The investment in expanding balsa plantations and developing processing facilities indicates a market confidence in the global balsa markets and some industry players suggest that the market could grow at about 7% annually (Xavier Bonet, Balsa-europe, pers comm.).

### The USA as an influence on global markets

The USA has traditionally been the major influence on global balsa markets due to its innovations in applications for end-grain balsa wood cores. In 1944, it accounted for 90% of global trade and imported some 80,000 $m^3$ valued, at that time, at US$2.7 million (Fletcher 1951) and in 2008 it imported 78,545 $m^3$ globally, valued at US$36.4 million (US Trade Statistics, Appendix 2). Figures from this study suggest that in 2008 the US market provided some 51% by both volume and value of global markets. In 2008, Ecuador supplied 94% of the US imports of balsa, consisting of 73,611 $m^3$, valued at around US$35.0 million (Table 7 and Appendix 2).

ITTO (2007a) recorded that balsa lumber was the most voluminous tropical wood imported by the USA in 2006 (35,760 $m^3$ or 20.2% of all US tropical lumber imports). From 2002 to 2006, balsa imports grew 310%, but in 2006 alone declined 46%; the reasons for this reduced volume are unclear although industry sources suggest that it may have been due to some manufacturers having built up inventories to accommodate anticipated projects.

**Table 7.** Volume and value of Ecuador balsa exports to the USA: 1999–2008. (Sources: US Trade Statistics; Pastor 2004, Vasquez 2005)

| US imports from Ecuador 1999–2008 | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Volume ('000 $m^3$) | 73 | 72 | 72 | 67 | 65 | 78 | 65 | 69 | 71 | 74 |
| Value (US$ million) | 20 | 15 | 17 | 18 | 19 | 26 | 24 | 28 | 31 | 35 |

In that period, balsa's ranking as an imported tropical wood to the USA changed from fifth in 2002 to first place in 2006. Most balsa supply (95%) originated in Ecuador. The ITTO records balsa shipments from South Africa but other records of these could not be located.

The ITTO figures offered in the 2007 report reflect the difficulty in locating reliable data for global balsa trade; it gave balsa imports as 35,760 $m^3$ valued at $13.9 million in 2006. US Trade Statistics (USDA FAS) suggest that imports were 70,956 $m^3$ valued at US$27.9 million in 2006 (see Appendix 2). The ITTO recorded an average price of US$388/$m^3$ for 2006 (ITTO 2007a) yet monthly reports suggest that these were consistently above US$400 for that year. The changing tariff codes at this time could partly explain these discrepancies.

Low demand, the credit crisis and higher costs had a serious impact on the US imports of balsa in 2009; US import statistics for January to May 2009 showed a 30% decline in the volume of balsa imports compared with the same period in 2008 and import values shrank from US$15 million to US$11 million. Among all the major imported tropical timbers, the reduction in balsa was much lower than for other species (ITTO 2009). This reduction has been confirmed by processors and exporters in PNG who have experienced slowing demand.

## Market prospects: can balsa remain competitive?

Most industry observers interviewed in the course of this study felt that the hobby and craft demands for balsa would remain static in the future and that any expansion in the global demand for balsa will be linked with the innovative industrial use of end-grain balsa panels in a range of applications. The prime competitors with balsa in these applications are synthetic foams; a summary of the competing foams and honeycombs used in cored sandwich composites is provided by Black (2003). Structural foam cores are manufactured from a number of thermosetting and thermoplastic polymers including polyvinyl chloride (PVC), polyurethane (PU), polystyrene (PS), styrene acrylonitrile (SAN), polyetherimide (PEI) and polymethacrylimide (PMI); these can be tailored for better compressive strength and greater temperature resistance than balsa. Flammability is an important consideration with foams, and where fire performance is an issue in transport applications such as high-speed marine vessels and trains, foams need to offer high-temperature performance, low-smoke density and halogen-free chemistry. These foam sheets, of varying strength and density ranging from 30 kg/$m^3$ up to 300 kg/$m^3$, offer considerable uniformity.

Foam sheets can be manufactured quickly in response to market demand. During the course of this study, a manufacturer of wind blades reported that the company would phase out use of balsa in favour of foams because of the capacity to develop manufacturing capacity quickly—if foams are required for a large new project, the response time is short, whereas there can be no guarantee that sufficient balsa will be available. Foams are, however, more expensive than end-grain balsa cores, which are seen as the low-cost entry point for manufacturers seeking to enter the cored-composites markets.

End-grain balsa cores combine high compressive and shear strength with excellent fatigue performance. Proponents of balsa wood point out that balsa is, in effect, a natural composite—bundles of cellulosic fibres are held together by lignin and, seen under a microscope, resemble a honeycomb.

Rather than compete with foams in high-technology, high-value applications, there is a body of opinion in the industry that sees balsa's logical place as a supplement to the particleboard and fibreboard industries and being used in furniture and construction applications. The alternative strategy suggested is to sell substantially greater volumes at lower prices.

### The expanding wind-energy sector

Industrial applications of balsa as a core composite appear to be expanding. Global wind-energy markets are expected to grow at an average rate of 13.8% per annum in terms of new capacity installation over the next 5 years (Lucintel 2009). Global investments in wind energy are substantial. In 2008, the USA invested some US$16 billion in the sector, to overtake Germany as the world's largest wind-power generator (The Economist 2009). The global economic crisis has caused some reflection upon continued investment, and some new wind-energy projects have been postponed. The American Wind Energy Association reported that, in 2008, generating capacity grew by 50% whereas in 2009 it forecast growth of only 20%—a figure that still offers substantial opportunities for core materials such as balsa. Investment in wind energy is expanding in China, which is now the fourth-largest producer of wind power after the USA, Germany and Spain (China Daily 2009) and new government policies relating to feed-in remuneration rates for wind power have been introduced and national renewable energy targets of 10% by 2010 and 15% by 2020 instituted. These policies have meant that many wind projects that in the past could often not be economically realised are now commercially feasible (Nordex 2009). China plans to build seven new wind-power facilities with a combined capacity of 120 gW, the construction of which will require an investment of about US$146 billion. This robust global growth is expected to drive production of new turbines and consequently increase the demand for composites at an annual rate of 18% (Lucintel 2009).

A wind turbine's major components include rotor blades, a gearbox and generator. The wind turbine blades are made primarily of fibreglass and balsa wood or other core materials and occasionally are strengthened with carbon fibre. There is little doubt that the fabrication of wind blades and other wind-turbine components offers enormous opportunity for the balsa industry.

As larger turbines are built and installed in more difficult environments, there is an overriding requirement to reduce blade weight, putting more emphasis on the need for stronger and lighter materials, improved blade design, and more efficient processing. Consequently, there will be a need for improved properties and or performance from current and or alternative materials used (Lucintel 2009).

The balsa industry must respond to these challenges and produce end-grain balsa panels of high quality to meet the demanding specifications of the wind-energy industry. This need is reflected in observations by industry (Box 2). Industry sources have noted a trend towards replacing balsa with polymers in the wind energy sector, but because the total wind market is growing so rapidly, an overall increase is expected in the demand for balsa over the next 10 years. New entrants in the wind-energy markets, such as China and India, are developing hybrid blades using both balsa and polymers, allowing them to enter the market quickly using existing, proven designs. Over time, as new companies mature in technology, know-how and engineering design capabilities, it is expected that some of this balsa will be replaced with polymer. Material suppliers to the wind-energy sector are confident that the polymer solution will provide a steadier and more reliable supply chain, yielding higher quality products with less delamination and variation and a longer operational life than balsa (DIAB, Sydney, pers. comm.).

With a rapidly expanding wind-energy industry driving the development of larger and larger turbines, the question is now arising of how to deal with wind turbines at the end of their life cycle—and particularly with those wind-turbine blades made from hard-to-recycle synthetic composites. Although balsa cores offer an obvious advantage over their competitors for recycling, many of the new polymers used for foams are recyclable (DIAB, Texas, pers. comm.).

## Ongoing use in other sectors

Material suppliers have noted a shift from balsa towards polymers in the marine sector in recent years; a shift encouraged by improved quality of polymers and technical problems with balsa. Europe now uses very little balsa in boats. The credit crisis has seen a marked recent downturn in the recreational marine markets (yachts, pleasure boats)—a contraction that has consequently reduced demand for balsa cores. The price-effectiveness of balsa and recent innovations to address issues relating to its use in boat hulls are expected to see the marine markets recover once the economic crisis has passed.

In other sectors, the future demand for balsa appears strong; the requirement for defence applications such as air cargo pallets and shelters remains robust. A call for expressions of interest to offer long-term supply of over 2,000 $m^3$/month of balsa to a single large global manufacturer of defence applications was circulated among PNG suppliers in late 2008—this would require a threefold increase in current supply. In the land transport sector, lightweight balsa panels remain popular for trucks, motor car and rail applications.

Despite competition from foams, balsa has maintained a strong market presence in the core composites sector over recent years. The green, renewable and environmentally friendly credentials of balsa over rival core materials are widely promoted by the global balsa industry and offer a credible rationale for its continued use. Translating this rationale into market success will require ongoing innovation and adaptation, as demonstrated by the market's largest player, Alcan Baltek (see Box 1).

## Box 2

## DIAB

DIAB Group AB Sweden is a wholly owned subsidiary of the Swedish private equity company Ratos AB, employs 1,280 people and had annual sales of US$203 million in 2008.

DIAB's business involves composite materials and sandwich technology. It is among the world's leading suppliers of materials for sandwich composites that make products stronger, lighter and more competitive. The company deals in a wide range of core materials including polyvinyl chloride (PVC), polyethylene terephthalate (PET) and balsa wood. DIAB's target markets are wind energy, marine, transportation, aerospace and industry where its products are used in various applications in boats, wind turbines, aircraft, buses, trains and trucks.

It is a global company with sales and customer support in 17 countries and 9 strategically located manufacturing units in Italy, Sweden, the United States of America (USA), Ecuador, Australia, China, India, Lithuania and Thailand producing advanced core materials under the name Divinycell® and Klegecell®, as well as high-quality ProBalsa® balsa wood products.

DIAB recognises balsa as an important part of the suite of products it offers its clients and accounts for about 25% of the global trade in raw balsa products. After importing balsa blocks from Ecuador into the USA for many years, the company opened its own processing facility in Ecuador in 2005 to build blocks and convert them to finished end-grain sheets. The facility, based in Guayaquil, now has the capacity to export up to 25 containers per month, or over 12,000 $m^3$ annually. DIAB provides technical support to a network of block suppliers who manufacture blocks to DIAB's demanding standards.

The need for a stable and reliable supply of raw material encouraged DIAB to establish over 100 ha of balsa plantations in Ecuador and the company has plans to expand this to 800 ha which will meet 25% of their green wood needs. The plantations are professionally managed and are supported by a research and development (R&D) program designed to maximise yields and shorten rotations. The remaining requirement for raw materials is sourced from a network of growers who maintain wood collection points at strategic geographic locations. Growers are offered training in plantation management and provided seedlings of high genetic quality. The company maintains a number of portable sawmills to cut logs into flitches at the plantation site.

DIAB has recently established a facility in China, similar to its one in Sydney, to process balsa blocks into plain and fibreglass-backed end-grain sheets.

DIAB has noted market shifts in the preferences of clients in the engineered core products sectors, particularly marine and wind energy. Marine demand for balsa has declined due to a market preference for polymer cores. The total wind market is expanding rapidly and a steady and increased demand for balsa is expected over the next 10 years, but demand for polymer will grow faster than that for balsa. In the most recent annual report (April 2009), the chief executive officer noted:

> There is a strong trend towards increased use of polymeric core material instead of balsa wood that is still used by certain blade manufacturers. To use polymer materials implies lower risk because they entail a more stable and efficient production process, better delivery reliability, lower production costs, and do not degenerate with moisture. These are significant advantages that affect the entire life cycle costs very positively. DIAB anticipates a similar development within the wind-energy industry as within the marine segment, where balsa wood in boats has almost disappeared.

DIAB expects that balsa will remain a part of its engineered core materials business for at least 10 years.

DIAB's background contributions to this study, the supply of product samples and visits to its processing factories are acknowledged. For further details on DIAB, visit its website (DIAB 2010).

# Marketing balsa from Papua New Guinea

The domestic markets for balsa in PNG are limited by the capacity and sophistication of PNG companies to manufacture a range of products. The limited availability of technical skills and infrastructure such as spare parts, workshops, electricians and other basic services suggests a need to seek industrial partners that would take the semi-processed products from PNG and complete final processing and product manufacture.

The processors in PNG have worked well to win an 8% share of the global balsa market against sustained international competition. This has been achieved by offering a broad product mix and responding to new and expanding markets in China and India. Market intelligence suggests that demand for balsa from PNG over the short-to-medium term is expected to be strong for most grades, the exception being the lightest grades used in the marine and pleasure-craft markets.

In the longer term, both growers and processors must accommodate market volatility. Increased demand and/or product shortages can lead to price increases that prompt expanded plantings; in turn, these can lead to oversupply and consequent falls in prices. This volatility is challenging for the balsa sector, where there is a 5–7 year lead time between changes in demand for balsa and a supply response from plantation managers and where there is limited opportunity to hold maturing stands beyond their normal felling age.

The most vulnerable part of the balsa supply chain in ENB relates to international marketing. There is little doubt that balsa grows well and that there is sufficient land and facilities to support a balsa industry. However, the capacity of the ENB industry to maintain and expand its position in international markets will be influenced by the effectiveness of its marketing in expanding its current 8% market share. On the assumption that global markets for balsa products grow at 5% annually, world markets may reach 188,000 $m^3$ in 2012 and be worth an estimated US$86 million. By this time, PNG's potential annual exports are expected to reach 57,000 $m^3$, worth an estimated US$26 million[6]. This represents an increase in global market share from 8% to almost 30% in volume terms and from 6% to 30% in value terms. The challenge for the PNG industry will be to expand and then sustain market share.

Achieving this goal will require more effective and focused marketing and broader use of balsa panels in the emerging economies of India and China, where market demand is growing. Market changes of the magnitude suggested will require a change from the relatively passive marketing style currently practised by individual processors to a more united, focused and innovative style promoting the credentials of balsa from PNG.

The targets for a marketing program would logically include industries that will respond to the environmental credentials of balsa, such as the wind-power sector. It is logical that the financiers who support large, environmentally sensitive wind-power projects would be keen to see environmentally friendly, recyclable products used in these projects. The engineers who design and manage such projects will need to be sure that balsa meets design specifications. The environmental credentials of balsa would be enhanced through certification of the balsa plantations. Certification offers manufacturers and proponents of large projects reassurance that their materials are sustainably produced.

The consequences of failing to effectively respond to these market opportunities will be a downturn in PNG's balsa industry with concomitant impacts on the already stressed economy of ENB and possible social dissatisfaction. The benefits of a positive and sustained response to market opportunities will be a significant boost for balsa producers and processors and for the socio-economy of ENB.

## Shipping

Shipping costs can greatly influence the capacity of balsa from PNG to remain competitive against rival products from Ecuador and synthetic foams. Balsa is shipped in 20- or 40-foot containers ('20-foot equivalent units', TEUs, or '40-foot equivalent units', FEUs) in international trade. Typically a TEU will hold 22–28 $m^3$ of product and an FEU 45–57 $m^3$ of product, depending on the nature of the cargo and whether it is packed in cardboard cartons and stacked on pallets. The Chinese market is said to prefer FEU shipment as the port unit costs for containers of both sizes are similar. For this reason, there is also a preference for the taller, higher-volume 'high cube' (HC)

[6] Assuming a total estate of 6,200 ha managed on a 5-year cycle with 200 $m^3$/ha log yield at harvest and average recoveries of 23% and end product worth US$458/$m^3$.

containers if they are available. (High cube containers provide an extra 30 cm in height and 12% in volume compared to the standard general-purpose containers, and suit light or bulky cargo.)

Rabaul Port handles some 300,000 t of shipping annually and has two berths, a maximum depth of 10.2 m and can accommodate vessels with a length of 170 m. The largest vessels are 25,000 t. For the export of 12,700 $m^3$ in 2008, Rabaul dispatched some 388 containers of balsa or about 32 per month[7]. Using the same assumptions, when industry production reaches the anticipated 57,000 $m^3$ annually from 2012 onwards, container dispatches will increase to 1,758 annually or 146 per month. Demands on infrastructure will increase substantially, as will the need for port services and associated export documentation.

Industry interviews suggest that, in July 2009, the typical cost of ocean freight of an FEU from Ecuador to the east coast of the USA was US$3,000 and to Shanghai, US$2,800.

The global economic crisis has had significant impacts on international shipping—shipping rates became more competitive in 2009. This has offered Rabaul a new range of shipping options and in August 2009 it enjoyed some five overseas shipping companies providing a total of 5–7 vessel port calls per month. Typical ocean freight prices for an FEU from Rabaul were US$1,300 to Sydney and US$2,200 to Shanghai. To these figures, the bunker adjustment factor (BAF)[8] and other costs add some US$2,441 and US$2,093, respectively. Table 8 offers some estimates of shipping costs from Rabaul to both Sydney and Shanghai.

If PNG accepts the growing markets of China and India as clear targets for future export growth in balsa products, it is logical that all delivery costs should remain competitive and be kept to a minimum if the industry is to compete with Ecuador. The most consistent client feedback received by PNG exporters relates to late shipments, commonly caused by changed shipping schedules and delayed approvals and permits.

## Quoted prices for balsa products

Negotiated prices for plain and scrim-backed end-grain balsa panels are generally commercially sensitive within the balsa industry. Factory door prices for less valuable materials such as balsa blocks and glued blocks are more readily shared. The following price quotations (US$/$m^3$, factory door and FOB) for kiln-dried (10–12% moisture content) and packed material were obtained from the internet in May 2009 (Alibaba Group 2009). These quotations are the asking prices of suppliers. Prices

[7] Assuming one half of shipments used TEUs and one half FEUs, an average 50 $m^3$/FEU and 24 $m^3$/TEU

[8] An additional charge levied on the shippers to compensate for fluctuations in the price of the ship's fuel; also called bunker surcharge

**Table 8.** Estimates of costs (US$) related to 40-foot container (FEU)[a] shipment from Rabaul to Shanghai and Sydney (including quarantine and excluding customs) (August 2009)

| Item | Destination (from Rabaul to —) | |
|---|---|---|
| | Sydney | Shanghai |
| Ocean freight | 1,300 | 2,200 |
| Bunker adjustment factor (BAF) | 896 | 840 |
| Documentation fee | 75 | 75 |
| Port service charge (PSC) | 118 | 118 |
| International Ship and Port Facility Security Code (ISPS) | 5.30 | 0 |
| Quarantine fee | 287 | 0 |
| Depot charges | 0 | 0 |
| Unpacks (palletised) | 300 | 300 |
| Hand unpack | 470 | 470 |
| Lift in | 20 | 20 |
| Fumigation (per full container load; FCL) | 270 | 270 |
| Estimated total (per FEU) | 3,741 | 4,293 |
| Cost (US$/$m^3$) for shipping (assume average 50 $m^3$/FEU) | 74.82 | 85.86 |

[a]'High cube' containers cost $500 extra and provide about 12% greater volume

actually paid by buyers (sale prices) are agreed following subsequent negotiations between the seller and buyer and reflect matters such as volumes, timing of delivery and timber specifications. These factors contribute to the variability in the prices quoted for similar material, especially from Ecuador, where there are many suppliers and traders.

## Rough-sawn flitches in Papua New Guinea and Ecuador

In both countries, some processors purchase rough-sawn flitches from growers or intermediate processors. Very strict specifications for size, colour, density and cleanliness are applied in both countries to prevent inferior material entering the processing plants. Mill-door delivered prices quoted for these flitches in both countries in 2009 were:

*Ecuador:* US\$144/m$^3$ (US\$0.34/board foot), up from 2008 prices of US\$118/m$^3$ (US\$0.28/board foot).

*PNG:* PGK450/m$^3$ (US\$170/m$^3$), up from PGK420/m$^3$ (US\$159/m$^3$) in 2008.

## Finished products

### *Ecuador*

*Company 1 (factory door)*. Balsa wood blocks (1 m (40 inches), various dimensions), US\$480–800

*Company 2 (FOB)*. End-grain balsa wood panels (0.6 m × 1.2 m (2 feet × 4 feet), various thicknesses), US\$840

*Company 3 (FOB)*. Balsa wood blocks (1 m, various dimensions >240 kg/m$^3$), US\$510
- Lightweight balsa blocks:
  - Grade A (64–100 kg/m$^3$), US\$657
  - Grade B (101–160 kg/m$^3$), US\$572
  - Grade C (160–240 kg/m$^3$), US\$530
- End-grain balsa wood panels—all density grades (0.6 m × 1.2 m × 5 cm (2 feet × 4 feet × 2 inches)), US\$800
- Balsa sheets:
  - Grade A (64–160 kg/m$^3$), US\$1,696
  - Grade B (161–256 kg/m$^3$), US\$1,484
  - Grade C (>256 kg/m$^3$), US\$1,272
- Balsa glued blocks (0.6 m × 1.2 m (2 feet × 4 feet), thickness 23–122 cm (9–48 inches)): All density categories, US\$690

*Company 4.* Balsa wood blocks (1 m (40 inches), various dimensions), US\$382

### *Indonesia*

*Company 1*. Balsa wood blocks (1 m (40 inches), various dimensions), US\$440–500

*Company 2*. Balsa wood blocks (1 m, various dimensions), US\$450

*Company 3*. Balsa wood blocks (1 m, various dimensions), US\$460–520

### *Brazil*

*Company 1*. Balsa wood blocks (1 m, various dimensions):
- Very light density (80–100 kg/m$^3$), US\$700
- Light density (101–150 kg/m$^3$), US\$550
- Medium density (>150 kg/m$^3$), US\$450

# The socioeconomy of balsa smallholdings in East New Britain

## Legislation

Balsa management, harvesting, haulage and processing in PNG are governed by various Acts and their principal provisions. These Acts and associated laws are binding on all stakeholders engaged with the balsa industry and include (Anon. 2000):

- *Forestry Act 1991 (as amended)* and its Regulations 1998.
- *Investment Promotion Act 1992*
- *Environmental Planning Act*, Chapter 370
- *Water Resources Act*, Chapter 205
- *Environmental Contaminants Act*, Chapter 368
- *Conservation Areas Act 1978*
- *Public Health Act*, Chapter 226 and Regulations on Drinking Water 1984
- PNG labour laws pertaining to *Industrial Safety, Health and Welfare Act*, Chapter 175, including Orders and Regulations
- *Land Transport Board Act* as amended No. 11 of 1991
- *Civil Aviation Act*, Chapter 239
- *Public Works Committee Act*, Chapter 28
- *Land Groups Incorporation Act*, Chapter 147.

Under the current legislation, balsa is considered a forest tree and is bound by the Forestry Act and its Regulations.

## Government agencies

### The Papua New Guinea Forest Authority (PNGFA)

PNGFA was established in 1993 under the *Forestry Act 1991*, replacing the former Department of Forests and unifying all Provincial Forest Divisions and the Forest Industries Council. These changes were a direct result of the 1989 Barnett Commission of Inquiry into the PNG forestry industry. The balsa industry in ENB falls within the New Guinea Islands (NGI) region of PNGFA that is managed from offices at Keravat. In addition, there are Provincial Forest Management Committees that include major stakeholders and whose role is to provide a forum for consultation and coordination on forest management between national and provincial governments and to make recommendations on matters related to forestry.

The Reforestation Supervisor, based in the NGI Regional Office at Keravat, provides the PNGFA focus for balsa and runs a small extension service, mainly offering balsa seedlings for a nominal PGK0.30 each. Growers will typically purchase consignments of 500 seedlings at a time. The supervisor also acts as a conduit for stumpage payments between the processor and the grower, with processors delivering stumpage cheques to the PNGFA office and the growers collecting their cheques from PNGFA. The supervisor may also withhold payment if there is a dispute over resource ownership that requires resolution.

### The Papua New Guinea Forest Research Institute (PNGFRI)

PNGFRI is the research arm of PNGFA and is based at Lae, Morobe province. It is mandated to conduct forest research in line with the National Forest Policy (1990). Its mission is to provide a scientific basis for the management of PNG's forest resources and to do this it has four program areas—natural forest management, planted forest, forest biology and forest products.

PNGFRI has a clear mandate to accommodate the research needs of the plantation balsa industry through its stated goals, which are to:

- improve germplasm of tree species for increased productivity and profitability
- aim for sustainable management of new and existing plantations for supply of certified quality timber for domestic and international markets

- promote utilisation of plantation and lesser-used species
- ensure efficiency of small- to medium-scale wood-processing mills.

Unfortunately, PNGFRI has limited resources and funding, limited expertise with the operations of balsa plantations and its location is remote from the balsa-growing areas of ENB. The balsa growers of ENB were largely unaware of the mandate and work of PNGFRI and questioned the relevance of a distant organisation to their industry.

### National Agricultural Research Institute (NARI)

The Lowlands Agricultural Extension Station (LAES), part of NARI, is located at Keravat, and is central to the balsa-growing areas of the Gazelle Peninsula. This station is among the oldest and most respected of the agricultural research stations in the Pacific. While it has no specific mandate to conduct research on balsa (as a forest tree), it has a commitment to tropical tree crops and it maintains some valuable genetic assets of balsa candidate seed trees (CSTs) on its lands and is well experienced with cocoa, galip (*Canarium*), rubber, oil palm and many other tropical tree crops. NARI also faces challenges of resources and funding and there can be no guarantee that it will be able to offer support to the balsa industry or maintain support for balsa genetic resource plantings indefinitely.

## Company support for growers

In addition to basic tree improvement, the ITTO Project left a legacy of basic skills in the management of balsa plantations. A small part of the former extension activities of the project are maintained by the PNGFA New Guinea Islands Regional Office, but much of the responsibility for technical standards now falls upon operators in the private sector who also manage their own nurseries. Several processors have also become growers as they seek to secure resource supply: almost all of the expansion in the ENB plantation resource has been funded by private investors and processors. Two of the largest growers have appointed their own professional forestry staff to establish and manage their plantations and to coordinate harvesting operations and maintain some modest R&D. A common comment from the companies was that they felt ‘on their own’, with no sources of genuine expertise to support them. One company (PNG Balsa) has initiated a collaborative plan with the SPC’s FACT Project to develop a tree improvement plan for balsa, to meet the company’s needs for high-quality germplasm.

A number of other companies directly service the balsa industry: freight forwarding agents, port services suppliers and quarantine service providers. Interviews conducted as part of this study showed a confidence in the capacity of these companies to maintain a high standard of service as export volumes grow.

## The dynamics of balsa purchase

There are no standard stumpage rates for balsa in ENB and these have varied from PGK15/m$^3$ to PGK70/m$^3$ since 2002. Growers and processors negotiate stumpages, considering several factors including the following.

*Distance from the mill:* Unless there are exceptional circumstances, the maximum haulage distance is 40 km. Some of the roads are in a very poor state of repair and this detracts from stumpages offered.

*Quantity available:* The cost of mobilising harvesting and haulage crews and associated equipment is such that most processors are reluctant to harvest blocks of fewer than 25 trees.

*Maturity of resource (size):* Wood density changes with age, with younger trees producing a greater proportion of ‘light’ wood. Given the export markets available to PNG processors, there is a preference for trees that are aged 5 years. Larger trees are preferred as they offer better log-to-board recoveries in the mill.

*Accessibility (terrain and distance from the road):* No specialised logging equipment is used in the balsa sector apart from some chainsaws (and farm tractors). Logs are mostly manhandled to the roadside and loaded onto trucks by hand. Harvesters are reluctant to operate more than 40 m from a road or in steep gullies. Very few plantation blocks warrant the construction of expensive, special logging roads.

The stumpages recorded in this study varied from PGK30/m$^3$ to PGK50/m$^3$. Reports suggest that current supply is very tight and will remain so until 2011 when some of the new plantations will become productive. This pressure on supply has resulted in increasing stumpages. PNGFA is keen to establish a minimum stumpage of PGK20/m$^3$, but the status of this minimum price and the capacity of PNGFA to enforce a minimum price are unclear.

For reasons associated with quality control, processors are generally unwilling to purchase balsa logs at the mill door. Experience has shown that logs brought to this point by producers can be undersize and contain blue stain or red heart. Processors do, however, accept air-dried, rough-sawn flitches to strict specifications and pay PGK420–450/$m^3$ at the mill door.

Once negotiations are complete, the grower and the processor enter into an official balsa purchasing agreement (Appendix 3) signed by the grower (or grower's agent) and the purchaser (or purchaser's agent) and which records the negotiated stumpage, the location of the plantation and the grower's name. A copy of this document accompanies payment to the grower via the PNGFA office.

Balsa log tally sheets (Appendix 4) are used when recording the actual volume of logs removed from a plantation. Establishing a clear and transparent process through which logs can be accurately and efficiently measured and recorded remains a priority for most growers and processors. All stakeholders interviewed were keen to see a simple, uniform system developed, based upon transparency and trust. Some in the industry are keen for the log tally to be completed by qualified log scalers before the logs leave the site, while others argue that such an approach is impractical. PNGFA argues for the measuring system used for large native forest logs—that all logs should be measured five times (diameter twice at each end of the log plus length). In any one month, logs may be harvested at many sites and it is challenging to find sufficient qualified log scalers willing to spend long periods in the field. Processors complain that pressure can be applied by growers (via the *wantok* system, see earlier section 'Employment trends in Papua New Guinea') to upgrade logs or create false names. From 2012, some 6,000 balsa logs per day will be milled by processors on the Gazelle Peninsula—clearly, measuring and recording five measurements for each log will be impractical. Effective log scaling requires an open area where logs can be measured accurately without tally sheets becoming wet. There is a convincing argument for the log tally to be completed at the processing plant and there exists a strong challenge for all stakeholders to develop a simple, transparent system that everyone can trust.

## Regulations relating to balsa harvesting, processing and export

Under current legislation and regulations, balsa is considered a forest tree, but it is clearly different to native hardwoods or large-scale commercial plantations grown on government land. It has been suggested sometimes that a 'Timber Authority' (TA-01 or TA-05)[9] should be granted by PNGFA before harvesting rights can be provided. The larger processors can harvest from 20–50 growers in different locations each month—the efficient management and supervision of such a large number of Timber Authorities would be challenging.

Under the current Forestry Act and its Regulations, export permits are required for any shipments of balsa, regardless of size or value (ranging from commercial samples to container loads). These permits are issued by PNGFA and all require Ministerial signature and inspection by PNGFA officers and preparation of documentation in Port Moresby. The process typically takes 4 weeks. It is unclear what value this process adds to the balsa industry and how it assists the PNG industry to remain competitive in a global market.

## Employment in the East New Britain balsa industry

Data on employment within the balsa industry in ENB are not available, but indicative estimates can be made. The largest employer in the balsa industry is the PNG Balsa Company with around 1,500 employees—about 800 in the factory and 700 in the field. This company is the second-largest employer in ENB after the provincial government. GS Model Construction Ltd employs 100 in its mill at Keravat. Total employment in the processing, harvesting and transport sector is estimated to be around 1,800–2,000. This level represents a significant proportion, around 12–13%, of total employment in ENB.

The number of balsa growers in ENB is currently estimated to be 500. For example, the PNGFA New Guinea Islands Office has around 500 registered balsa growers on its books and to whom it supplies

9 A Timber Authority (TA) can be issued to landowners by PNGFA for small-scale operations on areas that are outside existing Forest Management Agreements. A TA-01 will facilitate harvesting of less than 5,000 $m^3$ annually of timber for domestic processing and TA-05 enables harvesting of timber in a plantation area.

seedlings. A similar estimate was suggested by PNG Balsa. Assuming that each of these grower households could conservatively have three workers, there would be total of around 1,500 balsa workers. Therefore, there could be between 3,000 and 4,000 persons employed in the balsa industry in ENB, making it a significant industry in the province. The multiplier effect of the balsa industry on other businesses, including transport and maintenance services, fuel and chemical suppliers, government services, port services and general retail services, adds further to its importance to the local economy and community. The balsa industry makes a significant contribution to the livelihoods of many families and individuals in the province. Its importance is expected to increase in coming years as smallholders grow balsa on land that was previously used for cocoa and as larger growers and processors implement expansion plans.

Expansion in the growing and processing segments of the industry over the next 5 years could see total employment increase beyond 4,500. However, employment growth in the balsa industry may be constrained by a number of the same factors as have been identified for the cocoa industry in ENB (Curry et al. 2007). In addition to these factors, the planned increase in the minimum wage rate for unskilled workers, who make up the bulk of the industry's employees, is likely to have a significant impact on the size and structure of the industry.

## Impact of the 2008–2009 minimum wage rate increase

The Minimum Wages Board (MWB) was established in 1972 with the mandate to determine the national minimum wage. The Board, consisting of representatives from government, private-sector employers, employees and the community, meets every 3 years. Minimum wages set since 1975 differentiated rural and urban wages, with urban wages 2.9 times higher than the rural minimum wage in 1975, when first set. In 1992, MWB deregulated minimum wages, allowing employers and employees greater flexibility in determining wages based on productivity and capacity to pay.

In December 2008, MWB recommended an increase in the minimum wage for unskilled workers to be phased in over 12 months from the date that the proposal is endorsed by the National Executive Council. MWB proposed a two-stage adjustment, with the first to increase the weekly rate from PGK37.20 to PGK75.68 and the second taking the minimum rate to PGK101.76. The rates were scheduled to take effect 26 weeks and 40 weeks after the effective date of the MWB determination. It was recommended that all employers, regardless of their intention to seek exemption from paying the higher rates due to incapacity to pay, must pay PGK50.16 per 44-hour working week (Kendeman 2009). Plantation workers and farm labourers were included among those who would benefit most from the new rates. It is significant that the minimum wages do not apply to smallholder growers and Land Settlement Scheme farmers (Matbob 2009).

The increase in the minimum wage rate is the first since 1992 and was based on changes in the Bank of PNG inflation rate since 1993. While the increase represents a significant change, many employers in PNG are already paying above minimum rates. Most of the plantation owners and processors that were contacted for this study indicated that they were paying the minimum wage rate to unskilled workers. So, for them the increase will be significant. It will affect the balsa processors, the larger plantations and harvesting and transport providers. Smallholders largely use family labour and if they use hired labour they are exempted. The challenge for smallholders may be to stem the out-migration of family labour seeking relatively high-paid employment in larger centres, although this may be a short-term challenge as demand for labour will contract due to the higher wages.

The MWB determination in some respects represents a welfare safety net for unskilled employees and will reduce the level of poverty among some groups in the community. It will greatly improve workers' capacity to pay for basic food items and meet education and health expenses. However, the higher rates may make it difficult for those individuals aspiring to enter the workforce. According to the PNG Chamber of Commerce, 'the higher the wage rates or minimum wage rates go up, the less people can make that transition from the subsistence lifestyle to the paid employment world' (ABC Radio Australia 2009).

The PNG Balsa Company, in its submission to MWB (Guy Cameron, Kokopo, ENB, PNG, pers. comm., 14 September 2009), pointed out the following consequences for growing, harvesting and processing of balsa associated with the proposed wage rate increase:

- With labour costs representing 80% of planting costs, unless labour costs can be kept at or near

current levels or labour on-costs such as housing, food and transport can be offset against wages, then higher planting costs will seriously affect survival of the company; current planting strategies would cease and mechanised planting would be introduced.
- Mechanisation of harvesting would be necessary to offset increased labour costs.
- In relation to balsa processing, the effect of the higher wage rate would be to reduce the international competitiveness of balsa from PNG, with balsa products and resources from Ecuador gaining market share; 60% of the company's workforce would be lost.

PNG Balsa would have to refocus its business strategy and 'mechanise planting, harvesting and manufacturing where possible' and 'move a significant portion of the downstream processing to Asia where the manufacturing environment is super competitive, supportive, welcoming and progressive'. The social and economic impact of this would be significant for ENB, especially when coupled with the reduction of cocoa production due to cocoa pod borer and reduced demand for exports associated with the global financial crisis. Given the social and economic importance of the balsa industry in ENB, strategies to offset the impacts of the higher wage rates in the industry are deserving of further research.

# Issues arising from grower and processor interviews

## Cocoa pod borer

The likely impact of the cocoa pod borer (CPB) in ENB has been discussed in an earlier chapter of this report ('The balsa growers'). The anticipated withdrawal of 30,000 ha from cocoa production might offer some opportunities to expand production of balsa, but expansion in plantation area must be matched by an expansion in export markets. Already the impacts of CPB were evident among families interviewed; household incomes had been substantially reduced and community expectations unfulfilled. There exists a hope that balsa cultivation will play a role in injecting much-needed funds into a local economy suffering the results of CPB.

## Log measurement

The issue of log measurement and volume calculation discussed above was raised during every discussion during the study. The practical limitations of cost and convenience in measuring up to 3,000 logs daily (in 2009) and 6,000 logs daily (in 2012) need to be carefully considered. Should measurements be conducted in the field or at the mill? What checks and balances need to be put in place? The draft 'code of conduct and practice' contains some volume tables that are generally accepted. It is not clear that the five measurements of each log suggested by some will add any greater precision to estimates of volume or that such a system would solve the underlying challenges of practicality, transparency and trust. Any system adopted for log measurement needs to have the support of all stakeholders.

## Wood recovery (field and mill)

The processors have a suite of export markets; not all processors have the same markets and their wood needs vary in terms of quantity and quality. For example, many industrial applications of balsa are independent of density, yet others are highly sensitive to this property. The hobby and model markets demand uniform, pale straw colour, while in end-grain balsa some colour variation is acceptable. There are some broadly held perceptions of wastage during plantation harvest. Fletcher (1949) recorded balsa harvest as appearing very wasteful in Ecuador and this still appears to be the case. Growers are keen to maximise the number and volume of logs removed from their plantations. The large volume of branch material, woody debris and reject logs left after harvesting gives an impression of waste. In the absence of specialised logging machinery, there were instances where logs had been left in steep gullies and acceptable logs sometimes left in the field. In 2009, balsa was in short supply and there was little commercial sense in leaving merchantable material in the field. One processing company had developed log-grading rules and specifications for balsa logs and these were being circulated among its grower clients to help explain why material was left in the field. Another grower followed harvest crews to make sure all merchantable logs were removed—he regularly added another 5% of volume. Wood recovery during balsa harvest remains a significant issue in the eyes of the growers and enhanced transparency and improved communication appear to be required.

In the mill, recovery of finished product from logs is low and is governed by the quality of the logs and the nature of the product required. Recovery of 1 mm balsa sheets for the models market can be as low as 5–7%. For larger balsa blocks, recoveries can be up to 28%. This study has used an average figure of 23% for finished recoveries. Improvements in sawing techniques to accommodate growth stresses could improve recoveries.

## Stumpages (prices)

Growers complained that they felt isolated when negotiating stumpage rates and that a need existed to make market information more readily available. There is no forum where growers can independently discuss stumpages and share market information. There are no newsletters, brochures or other tools that are normally available to people selling other commodity crops. On the other hand, processors felt that some growers had unrealistic expectations of the value of their balsa crop, based on export prices received for processed balsa products. The problems appear to be similar to those experienced by farming sectors in many other countries and will require improved communication to overcome them. Some in the industry expressed a view that a 'ready reckoner' for balsa stumpages, developed by both growers and processors, would assist the negotiation process.

## Can balsa growing remain profitable?

Given the small size of the plantation estate and the changing nature of export markets for balsa, uncertainty was expressed by both growers and processors regarding the long-term profitability and prospects for balsa. Land is generally the most significant asset owned by many growers and the decision to dedicate land for 5 years to a single crop is not taken lightly; reliable information is necessary. The costs, benefits and profitability of growing crops such as copra, cocoa or coffee are generally well known, as are international price trends. Greater access to data on costs and returns associated with balsa cultivation would be part of enhanced communication in the sector. The next chapter ('Profitability of balsa growing') offers more details of the costs and benefits associated with growing balsa.

## Marketing

The most vulnerable part of the balsa supply chain in ENB relates to international marketing (see earlier chapter, 'Trade and balsa markets'). There is little doubt that balsa grows well and that there is sufficient land and facilities to support a balsa industry. However, the capacity of the ENB industry to remain competitive and expand its current 8% share of the global markets to a possible 30% will be influenced by the effectiveness of its marketing. Stakeholders were concerned at the magnitude of the task and the consequences of failure.

## Communication and transparency

During interviews and the public forum hosted by the PNG Growers' Association in Kokopo, the need for added transparency and more effective communication within the sector was raised. There is no forum for discussion of balsa issues—where stakeholders can share information on prices, markets or silviculture. There is no forum where stakeholders can air legitimate grievances on stumpages, log measurement and perceptions of wastage, for example. Stakeholders expressed a strong desire for a clearly impartial mediator to assist with the resolution of such matters. Stakeholders felt that there needed to be better industry communication via newsletters, regular meetings and updated manuals. The PNG Growers' Association offered to explore an expanded role through involvement of both growers and processors with the Association.

## Governance

For the balsa sector to thrive and to maintain and expand PNG's share of global markets, it requires a supportive bureaucracy. Where international competition is strong, government processes must add value.

A major issue raised by most stakeholders surrounded governance. Logically, where does balsa belong? Is it an agricultural crop or a forest tree? Does it belong to the agriculture sector or the forestry sector? Such basic questions have serious consequences and, for example, influence which institution has the responsibility to provide R&D support. Which agency has the skills and resources to respond if there is a disease outbreak or if new germplasm is required? Which agency will offer long-term access to land to host experiments such as progeny trials or seedling seed orchards? NARI is located geographically at the centre of the industry and has previously provided land for experimental purposes; PNGFRI is far away in Lae. Balsa is part of the Provincial Agricultural Crops Diversification Strategy and all ENB growers regard it as a cash crop. It is an exotic plantation species repeatedly cropped by many landowners on 4–5-year rotations on private land and processed by private enterprises. Stakeholders question why it should be considered in the same basket as timbers such as kwila or teak. Industry stakeholders suggested that this issue added an unnecessary uncertainty to the industry and requested serious discussion and clarification.

Both grower and industry expectations were unfulfilled regarding extension, technical support and R&D from government sources. For example, copies of *The balsa manual* (Howcroft 2002) were not available to growers and no investment had been made in maintaining the suite of CSTs identified during the ITTO Project.

The second issue involving governance, also raised by most stakeholders, was the role of government. Stakeholders favoured a role for a supportive bureaucracy, but felt that this role should be focused and that existing processes were lengthy and lacked focus. An example of this is the need to obtain export permits through PNGFA for every export consignment. These permits require Ministerial signature and the process can take 4 weeks to inspect the consignment, arrange and prepare the documentation and send materials to Port Moresby for signing by the Minister. There are no exceptions to this requirement and it applies to every consignment—whether it is a container or a small carton of commercial samples. Another example is the ongoing threat to impose a requirement for industry participants (both growers and processors) to apply for Timber Authorities; growers question the appropriateness of this administrative procedure for balsa grown on the Gazelle Peninsula.

PNGFA has reportedly convened a Balsa Working Group to examine and report on matters relating to the balsa industry. Attempts by the study team to meet members of the group were unsuccessful, and its role, terms of reference and authority were unclear to both the team and the industry.

# Profitability of balsa growing

In ENB, balsa is grown under a range of management systems including large plantations on private land, smallholdings of individual households on customary land and landowner groups of individuals who pool their plantation assets to achieve economies of scale in production and marketing. Many of the balsa processors have integrated operations, drawing a portion of their resources from their own plantations.

The financial analyses presented here are for three production systems: smallholders, share-farming with landowner groups and a balsa processor, and large-scale plantations including integrated processors. Major differences between smallholders and large plantation owners and managers are in the areas of silvicultural practices and labour management. Shortages of knowledge and labour are common constraints among smallholders, contributing to lower yields and variable resource quality. The larger plantations owners and managers practise advanced silvicultural management and ensure that adequate supplies of labour and other key inputs are available. Consequently, productivity on larger plantations is substantially higher than on smaller holdings. The profitability of the three production systems is explored in this chapter.

## Production data and information sources

Data and information for the financial assessments were obtained from primary and secondary sources. Data were collected from a sample of growers and processors on the Gazelle Peninsula during July 2009 via semi-structured interviews. Data and information were collected through less formal interviews with other key industry participants including PNGFA New Guinea Islands and the ENB Branch of the PNG Growers' Association. Table 9 presents details of the information and data collection. Secondary data sources used include *The balsa manual* developed under an ITTO project (Howcroft 2002) and a study by Metlak Development Corporation (2004) on the viability of establishing a balsa enterprise in New Ireland province.

**Table 9.** Information and data collection

| Industry participants | Number interviewed | Comment |
|---|---|---|
| Smallholder growers | 2 | Growers with <5 ha balsa; data supplemented by information provided by industry participants |
| Grower groups | 2 | Growers who are members of a registered landowner group; similar data to those for individual households but economies of size achieved; group overhead costs; higher yields and prices; many have a supply agreement with a processor |
| Large plantation owners | 1 | Growers with >10 ha balsa demonstrating the potential benefits offered by a well-managed balsa plantation (good silvicultural practices) |
| Integrated grower–processors | 3 | Similar production conditions to large plantation owners; some operate a nucleus estate with larger plantation owners and grower groups |
| Balsa processors | 1 | Small- to medium-scale processors with set-up for sawing, drying and balsa finishing |

### Measures of profitability

Discounted cash-flow analysis was applied to assess the profitability of each balsa production system. Several measures were used to indicate profitability. These include net present value, internal rate of return, annual equivalent value, break-even price and return to labour. Profitability was assessed for a 10-year period, effectively covering two balsa rotations. Net present value (NPV) is the sum of the flow of annual net returns, each of which is expressed as a present value. A present value is the equivalent value today of a future cost or revenue. Discount rates are used to calculate present values.

The discount rate allows all costs and returns incurred in future periods to be expressed in equivalent present-value terms. A discount rate of 10% was used for determining the NPV of the balsa production systems analysed. Sensitivity of the results can be explored for alternative discount rates. If the NPV is >0, then the activity or investment is profitable.

The internal rate of return (IRR) is the discount rate that equates the present value of the revenues with the present value of the costs of a project. It is the rate at which the NPV of an investment is zero. If the IRR exceeds the discount rate, then the project or investment is profitable.

The annual equivalent value (AEV) is the annual equivalent of the NPV. AEV is an effective measure for comparing net returns from a land-use activity that spans several years, such as forestry, with an annual land-use activity such as cereal or vegetable cropping.

The break-even price is the farm-gate price paid to growers for balsa at which the NPV equals zero, where the activity just covers costs. Comparing the break-even price with the actual farm-gate price indicates the scope for absorbing cost increases or price falls. Break-even analysis can be conducted for key activity parameters such as timber yield and establishment, maintenance and labour costs.

The return to labour is the wage rate that sets the NPV equal to zero, or the break-even wage rate. It is the highest rate that can be paid for a labour input before the NPV becomes negative. Where the return to labour exceeds the minimum daily wage rate, individual land owners would be better off financially by applying their labour to growing balsa rather than paid employment. Return to labour is a useful primary indicator of profitability for smallholders.

The time period from plantation establishment to positive cash flow is another useful indicator for forestry investors. Revenue does not usually flow until several years after the establishment of a plantation and the biggest expenditure outlays occur in the early years of a plantation investment, so the sooner the cash flow turns positive the better for the investor.

## Profitability of smallholder balsa growing

Smallholder balsa growers are classed as those with plots of less than 5 ha. The number of smallholder balsa growers in ENB is not known precisely, although it has been estimated to be fewer than 400. Uncertainty about numbers of small households growing balsa has increased as a consequence of cocoa pod borer (CPB) and the management responses by cocoa growers. Balsa offers an attractive alternative land use for former cocoa growers. A survey of cocoa growers' land-use intentions in response to CPB would provide an indication of the number of smallholders (and larger land users) planning to move from cocoa into balsa production or to expand existing areas of balsa. Current ACIAR projects on cocoa and other crops in ENB may be able to provide this information (e.g. ACIAR Project No. PC/2006/114—'Managing cocoa pod borer in Papua New Guinea through improved risk incursion management capabilities, IPM strategies and stakeholder participatory training'; and Project No. FST/2004/055—'Domestication and commercialisation of *Canarium indicum* in Papua New Guinea'). Data on cocoa growers' future land-use intentions may have to be collected as part of a larger-scale research project on balsa production opportunities in ENB. The attractiveness of converting cocoa-growing land to balsa plantations will be governed by the capacity of the PNG balsa industry to remain internationally competitive and the ability of the processors to export balsa products.

Key information and data collected from smallholders are summarised in Table 10. The contents of this table are based on data and information provided during interviews with individual smallholders and growers who are members of a group, as explained in Table 9.

**Table 10.** Smallholder balsa growers: key indicators

| Indicator | Status | Comment |
|---|---|---|
| Labour supply | Family only for individual smallholders<br>Under contracts between grower groups and processors, all labour inputs are supplied by the processor | Adequate labour supply is a strength of the group system and a potential limitation for individual smallholders |
| Source of planting material | Individuals source seedlings from existing trees and the PNG Forest Authority (PNGFA) while group members source from the processor | Productivity advantages achieved by groups from improved seedlings |
| Planting rate | 1,110 seedlings/ha | Standard planting practice on a 3 m × 3 m pattern |
| Survival rate | 95–99% | If survival high, no replanting |
| Thinning | No (most growers) | One smallholder thinned<br>Some group members thin |
| Pruning | No (most growers) | One smallholder pruned<br>Some group members prune |
| Fertilising | No (all growers) | None |
| Weeding | Yes (all growers) | Essential in first year |
| Pest and disease management | No (all growers) | Some monitoring |
| Seedling cost per unit | PGK0.3 to PGK0.4 | Standard price |
| Source of technical information | Other growers; processing company | One used PNGFA |
| Harvest age | 5 years | Standard practice |
| Method of selling | Standing tree | Standard practice |
| Buyer | Primary processor | Standard practice |
| Price per $m^3$ | By negotiation<br>Ranges from PGK35 to PGK60<br>Purchase agreement or supply contract | Group members received higher prices; higher prices are associated with being nearer to processor and quality |
| Distance to processor | Ranged from 28 km to 45 km | Higher farm-gate prices for resources located closer to processing mills |
| Source of market information | Ranged from none, by group members, to other growers | Exposure to market information is limited |
| Knowledge of quality requirements | Ranged from poor to good | Most growers advised that they had poor knowledge of quality attributes |
| Replanting intentions | Majority intend to replant balsa after current crop | One exception was because prices were considered to be low |
| Research and development needs | Yes | Needs included:<br>• access to improved germplasm<br>• improved relations between growers and processors |
| Motivation | Low costs of establishment<br>Good returns in a short period | Especially attractive for landowner groups who have contracts with processors |
| Constraints | Grower cooperation<br>Prices received<br>Resource wastage<br>Lack of transparency<br>Information flow to growers | Internal communication of industry information is a key constraint |

Using the information reported in Table 10 and from other sources as noted in the previous section, a discounted cash-flow analysis was conducted for a typical smallholder balsa grower to establish indicators of profitability. The profile of a typical smallholder grower is presented in Table 11.

Table 12 and Figure 17 present the results of the discounted cash-flow analysis for a smallholder balsa grower in ENB. The results in Table 12 reveal that, despite a very low timber yield (estimated to be 180 $m^3$/ha at year 5) associated with a low standard of stand management, balsa is a very profitable land-use option for smallholders. At a higher yield of 200 $m^3$/ha with the same level of labour inputs, the IRR increases to 42% in line with higher NPVs and AEVs for each discount rate (data not shown). This alternative assumes that labour inputs are applied more effectively, without any additional costs.

Figure 17 indicates that the cumulative discounted net cash flow, after falling to minus PGK2,043 in year 4, turns positive in year 5 when the first crop is harvested. Smallholder growers have to compare this outcome with other land-use options, especially other perennial crops. For example, balsa generates a positive cash flow sooner than galip nut, an alternative land-use option (John Moxon, LAES, NARI, Keravat, ENB, pers. comm., July 2009). While galip is an attractive investment proposition for smallholders in NPV and IRR terms, discounted cumulative net cash flow does not turn positive until 12 years after establishment compared to 5 years for balsa.

**Table 11.** Profile of a smallholder of balsa grower, East New Britain

| Key parameter | Level | Comment |
|---|---|---|
| Land preparation | 24 person-days (pd)/ha in year 1<br>10 pd/ha for second rotation | Assumes that land was previously fallow (garden) |
| Planting | 25 pd/ha | Includes lining, holing and planting |
| Stocking rate | 1,110 stems per ha | 3 m × 3 m |
| Seedling survival | 99% | Based on grower feedback |
| Replanting | None | |
| Seedling costs (including transport from source) | PGK0.3 per seedling<br>PGK0.05 per seedling transport | Transport costs based on 60 km round trip to collect sufficient seedlings for 1 ha |
| Weeding | 24 pd/ha in year 1<br>18 pd/ha in year 2 | First rotation |
| | 18 pd/ha in year 1<br>12 pd/ha in year 2 | Second rotation |
| Thinning and pruning | None | |
| Fertilising | None | |
| Harvesting | 2 pd/ha | Harvesting and transport are arranged by the processor; the grower's labour input is equivalent to monitoring |
| Stumpage price[a] | PGK35/$m^3$ | Price is net of the costs of harvesting and transport to the mill |
| Yield at end of rotation | 180 $m^3$/ha | Conservatively low |
| Cost of labour | PGK15.14/day | New minimum wage, first level increase |
| Source of labour | Family | Adequate labour available |
| Establishment costs | PGK1,528.40/ha | Labour represents 74% of total establishment costs (assumes that land was previously fallow) |
| Maintenance costs per ha:<br>Year 2<br>Year 3–4<br>Year 5 | <br>PGK302.80<br>PGK30.28<br>PGK60.56 | <br>Weeding and tending<br>Tending only (minimal labour input)<br>Tending and harvest support |

[a] Stumpage is nominally the price paid to a grower by the harvesting contractor for trees standing in a plantation, but in the case of balsa the price paid is based on the volume of balsa logs removed, as not all trees are of acceptable quality.

## The impact of labour supply on smallholder balsa profitability

Balsa establishment costs in the first year are PGK1,528/ha. The cost of labour is included at PGK15.14 a day but, in reality, smallholders use family labour for which they do not pay wages. The head of the household, however, does compensate family labour with a share of the income from the balsa harvest once it is received. The financial commitment of the smallholder in the first year therefore is largely the cost of seedlings, which is almost PGK393/ha or 26% of total establishment costs. This is unlikely to be a burden. Feedback from smallholder growers interviewed for this study indicated that they do not borrow money, preferring to use their own funds. Furthermore, they consider the establishment costs for balsa to be relatively low, which is part of their attraction to the crop.

Smallholders depend heavily on access to a reliable and adequate supply of labour from their family. It is assumed for this assessment that labour supply is unconstrained, although this may not always be the case. If the balsa enterprise has to compete for labour with other demands such as other agricultural activities (e.g. cocoa, coconut or galip nut), subsistence gardening or personal and community commitments, this competition will influence the area of balsa that can be established and tended. Balsa establishment and maintenance is very labour-intensive in the first year; successful establishment depends on availability of labour. It is estimated that, on average in the first 12 months, the equivalent of 95 person-days of labour is required for 1 ha of balsa. This should be achievable by a smallholder with two or three family members available for farm work. Labour supply and labour management are key issues for smallholders, especially as the area of balsa increases. Labour is likely to be the most limiting resource for small-holder balsa production. Labour availability will affect balsa productivity, as it does for other crops

**Table 12.** Indicators of profitability for smallholder balsa growing in East New Britain

| Measure | Baseline | Discount rate | | |
|---|---|---|---|---|
| | | 10% | 15% | 20% |
| Net present value (PGK/ha) | ≥ 0 | 4,048 | 2,667 | 1,689 |
| Internal rate of return (%) | > Discount rate | 36 | 36 | 36 |
| Annual equivalent value (PGK/ha) | > Annual returns from other land uses | 659 | 532 | 403 |
| Break-even balsa stumpage price (PGK/m$^3$) | 35 | 14.69 | 17.69 | 21.12 |
| Return to labour (PGK/day) | ≥ 15.14 to ≥ 20.15 | 50.47 | 40.67 | 32.60 |

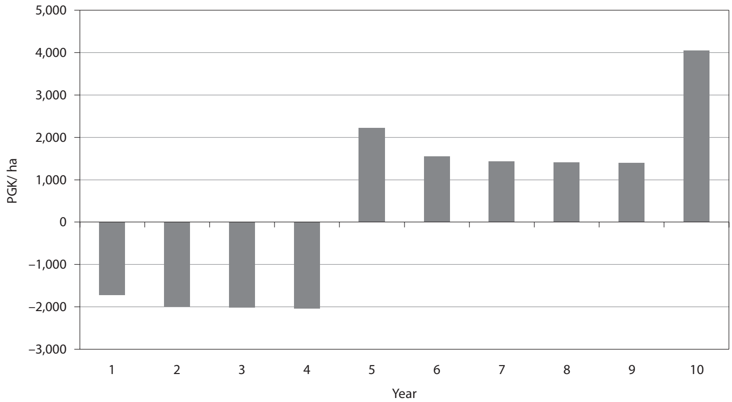


**Figure 17.** Cumulative discounted net cash flow for smallholder balsa production at a 10% discount rate

(e.g. for cocoa production in ENB, see Curry et al. 2007). On balance, while smallholder balsa production is profitable and returns are generated in a relatively short time, certainty of labour supply and long-term commitment to sustained production indicate that smallholders may be an unreliable source of balsa supply.

## Profitability of balsa grower groups in share-farming arrangements with processors

A number of households growing balsa in ENB are members of a landowner group. A group is able to achieve economies of size in a number of areas, resulting in higher returns per hectare for individual growers. The advantages of growing balsa within a landowner group compared with an independent smallholder operation include:

- a supply contract with a local processor, based on volume and wood quality attributes
- higher timber yields associated with more silvicultural inputs than used by independent smallholders; 200–240 $m^3$/ha at year 5 (220 $m^3$/ha was used in the assessment of profitability in this study)
- under the terms of the supply contract, all preparation, establishment and maintenance operations are conducted by the processor at no cost to the grower
- higher farm-gate prices per cubic metre for balsa logs—PGK40–60/$m^3$ (PGK40/$m^3$ was used in the assessment of profitability in this study).

Balsa establishment and maintenance operations are similar to those practised by independent smallholders. For example, the planting rate is 1,110 seedlings/ha, seedling survival is 99%, the rotation length is 5 years and the selling method is standing trees. Where groups differ from independent smallholders is that they are more committed to long-term production of balsa and they are supported by supply contracts with processors. Processors specify acceptable quality standards for balsa resources and they provide good-quality seedlings and technical services to growers. Thinning and pruning are more likely to occur under a supply contract, although many landowners are reluctant to allow these silvicultural practices. Establishment and maintenance costs covered by the processor include site preparation, seedling supply, planting, weeding, thinning, pruning and maintenance. The returns from balsa sales are split 50:50 between the grower and the processor. Therefore, for an agreed stumpage price of PGK40/$m^3$, the grower receives PGK20/$m^3$ for resources transported to the mill. It is a type of share-farming agreement between a balsa processor and a grower group. In the case of one processor, it is stipulated that the landowner must have a registered title of tenure. This provides greater security of supply for the processor as there is unlikely to be any dispute over ownership of the land.

The main benefits for processors from share-farming agreements with groups compared to dealing with several independent growers include:

- more reliable and predictable supply of good-quality balsa resources
- greater control over the supply chain from seed to product
- certainty of throughput.

In this study, the profitability of grower groups has been estimated separately for an individual grower-group member and for a processor, as well as for the system as a whole.

### Profitability for growers

Table 13 indicates the profitability of a share-farming production system for a member of a grower group. It is a highly attractive option for growers. The only input they provide is their land. The indicators of profitability in Table 13 reflect the low-cost production system—there is no allowance included for the cost of the land[10]. Compared to the estimated profitability for an independent smallholder (Table 12), the grower group member is better off by around 10% in terms of NPV and AEV. The figures for IRR and return to labour reflect the cost structure of the production system.

The break-even price is unrealistic as the price has to be acceptable to both the processor and the grower. However, it also is indicative of the low-cost structure for members of grower groups. Figure 18 reveals the cumulative cash-flow situation for a grower-group member. The small negative amounts are for occasional labour inputs by the landowner to tend and monitor the balsa crop. This is the

[10] One option for an analysis such as this is to include the equivalent of a land rental price but, as renting is not common in PNG, the opportunity costs of the land could be substituted—i.e. the annual return per hectare from the next-best alternative use.

landowner's contribution to the security of the timber resources.

## Profitability for processors

The profitability measures for the processor partner in a balsa share-farming agreement with a grower group are presented in Table 14. The results reveal that the while this supply option is profitable for processors at the 10% discount rate, growers receive a better outcome from the arrangement. In fact, at the 20% discount rate, the grower-group option is not profitable for the processor, and even at 15% it is a doubtful proposition. Processors carry a higher share of the risk of loss associated with storms, disease, landowner disputes, political instability, fluctuations in market demand and exchange-rate movements.

The 15% discount rate is a more appropriate rate to use for an assessment of the share-farming production system from the perspective of the processor. Based on the results of the analysis presented in Table 14, it is concluded that grower groups are a profitable but risky option for processors at 10% and 15% discount rates, but are not profitable at the 20% discount rate. When compared with less reliable and inconsistent balsa supplies from independent growers, however, the grower-group share-farming option is more attractive and less risky for processors. Further research into the risk factors is warranted to identify critical risks to the success of this balsa production system.

The return-to-labour measure of profitability is marginal at the 15% discount level. The baseline daily rate of PGK23.15 includes the first-level increase in the minimum wage (see previous chapter) plus labour on-costs of PGK8.00 that companies incur to cover the costs of employment.

The discounted cumulative net cash flow for the processor in a share-farming agreement with a grower group indicates that strong positive returns do not occur until after the second balsa crop (Figure 19). The balsa processor must have the financial capacity to withstand several years of negative returns. The landowner's short-term cash-

**Table 13.** Indicators of profitability for an individual member of balsa grower group in East New Britain

| Measure | Baseline | Discount rate | | |
|---|---|---|---|---|
| | | 10% | 15% | 20% |
| Net present value (PGK/ha) | ≥ 0 | 4,667 | 3,592 | 2,531 |
| Internal rate of return (%) | > Discount rate | 216 | 216 | 223 |
| Annual equivalent value (PGK/ha) | > Annual returns for other land uses | 759 | 716 | 604 |
| Break-even balsa stumpage price (PGK/m$^3$) | 40 | 0.84 | 0.93 | 1.03 |
| Return to labour (PGK/day) | ≥ 20.15 | 360.35 | 326.30 | 295.60 |

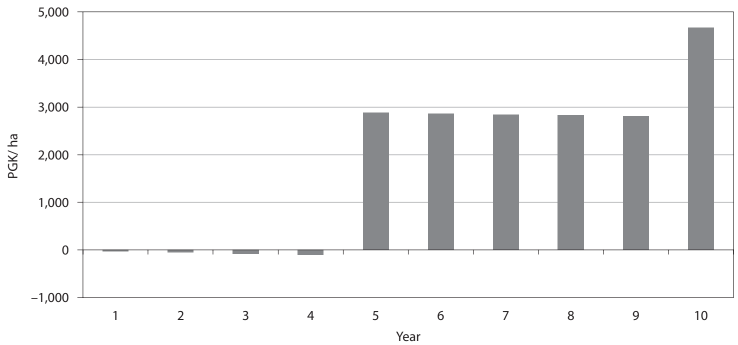


**Figure 18.** Cumulative discounted net cash flow for balsa grower group member at a 10% discount rate

flow situation is substantially better than that for the processor.

It is in the interest of processors to increase both the productivity of land under a share-farming agreement and the average quality of resources produced from that land. This will offset the risks and increase the supply of balsa with desired properties. In turn, this will increase the average resource price as a consequence of a higher proportion of the resources being of acceptable quality, especially with respect to disease and wood density. The challenge for processors is to convince landowners of the benefits of thinning and pruning that improve wood properties and yield. Many landowners see removal of trees as an absolute reduction in the volume of production. It will be necessary for processors to demonstrate the physical and financial benefits of thinning and pruning using appropriate participatory methods such as demonstration trials in landowners' fields and dissemination of suitable extension material. The effort to address this issue could be supported by specific project funding to encourage involvement of growers, processors and extension services in research on the benefits of improved silvicultural practices.

### Overall profitability of share-farming agreements between grower groups and processors

The profitability of the overall balsa share-farming systems is presented in Table 15. These results reveal that a share-farming system is highly profitable, with better returns for all measures except IRR (which is the same at 36%) than for independent small-scale balsa production. As the analyses for the individual partners revealed, however, the sustainability of the system depends on the profitability of the arrangement for the landowners and the processor independently.

**Table 14.** Indicators of profitability for a processor in a share-farming arrangement with a grower group in East New Britain

| Measure | Baseline | Discount rate | | |
|---|---|---|---|---|
| | | 10% | 15% | 20% |
| Net present value (PGK/ha) | ≥ 0 | 884 | 75 | –489 |
| Internal rate of return (%) | > Discount rate | 16 | 16 | 16 |
| Annual equivalent value (PGK/ha) | > Annual returns for other land uses | 144 | 15 | –120 |
| Break-even farm-gate balsa price (PGK/m$^3$) | 40 | 16.37 | 19.60 | 23.29 |
| Return to labour (PGK/day) | ≥ 23.15 | 29.08 | 23.68 | 19.37 |

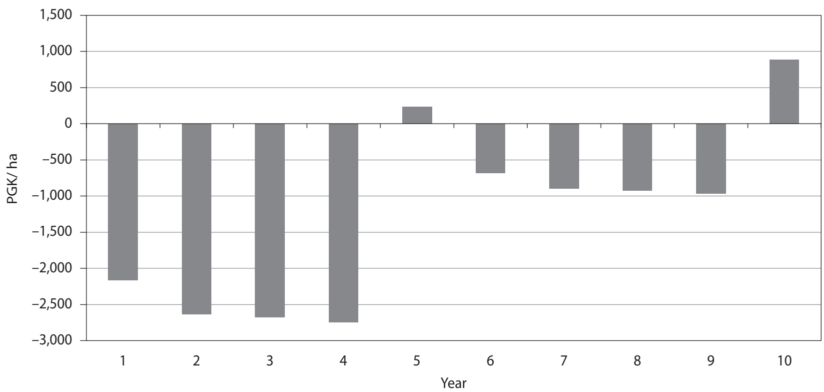


**Figure 19.** Cumulative discounted net cash flow for a balsa processor in a share-farming arrangement with a grower group at a 10% discount rate

Figure 20 shows a cumulative discounted net cash flow pattern similar to that for the independent smallholders but with higher returns associated with higher yields and prices.

The potential of grower groups to supply balsa resources in ENB is strong. One processor indicated that, in the future, in addition to their own resources, they will seek resources from only large-scale producers in order to meet quality standards for export contracts. These producers include large individual growers and grower groups. As indicated earlier, the contribution of independent smallholder growers to total balsa supply is expected to fall significantly over the next 5 years, while groups and larger growers will increase their share of total supply. The success of the system will depend on the capacity of the processor to bear the production, financing, marketing and other risks that are not insignificant. Individual landowners receive a good deal under these arrangements. Efforts to increase yields and the quality of resources will reward both landowners and processors, although the incentive for interventions is stronger for the processors, given the relative cost structures and risk profiles of the partners.

Balsa grower groups are based on registered landowner groups. There may be scope for improving the efficiency and effectiveness of grower groups in areas such as technology transfer, dissemination of market information, supply contract and service-provision negotiations, and maintenance of standards in growing, harvesting and transport of balsa. For example, grower groups may be an effective medium for introducing to growers silvicultural practices that will lead to higher yields and incomes and increase total balsa production. Landowner groups, however, normally do not operate with a management or governance structure. If a landowner group were to become more active in management then it would be able to carry some of the risk of production and negotiate alternative revenue-sharing arrangements with

**Table 15.** Indicators of the overall profitability of a balsa share-farming system in East New Britain

| Measure | Baseline | Discount rate | | |
|---|---|---|---|---|
| | | 10% | 15% | 20% |
| Net present value (PGK/ha) | ≥ 0 | 5,551 | 3,667 | 2,333 |
| Internal rate of return (%) | > Discount rate | 36 | 36 | 36 |
| Annual equivalent value (PGK/ha) | > Annual returns for other land uses | 903 | 731 | 556 |
| Break-even farm-gate balsa price (PGK/m$^3$) | 40 | 17.21 | 20.53 | 24.31 |
| Return to labour (PGK/day) | ≥ 23.15 | 60.41 | 49.72 | 41.15 |

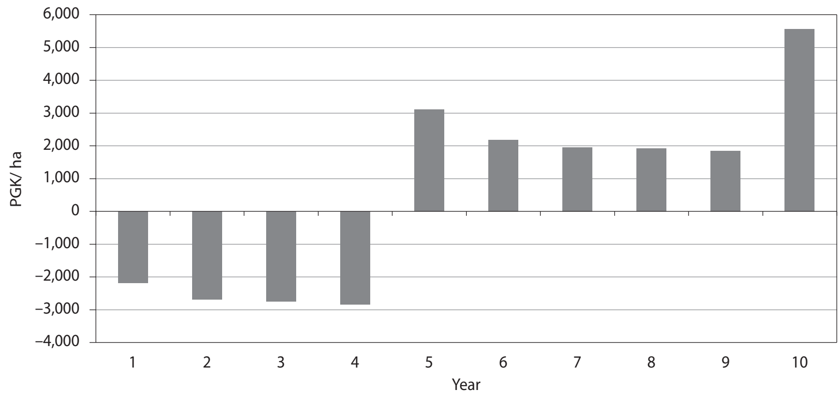


**Figure 20.** Cumulative discounted net cash flow for balsa share-farming system at a 10% discount rate

processors. The potential role and contribution of landowner groups should be included in further research into opportunities for balsa production, processing and marketing in ENB.

## Profitability of balsa growing for large-scale growers, including integrated grower–processors

Large-scale balsa growers include those with plantation areas of 10 ha or more. The level of investment required for such an area is generally beyond the financial and labour capacity of a smallholder. Integrated grower–processors include balsa processors that obtain some balsa resources from their own plantations. Key indicators for large-scale growers and integrated grower–processors are presented in Table 16.

The data and information listed for large-scale growers in Table 16 can be compared to those for small-scale balsa growers listed in Table 10. A comparison reveals that large balsa growers differ from small growers in the following areas:

- using good-quality seedlings at slightly higher cost
- infilling or replacing seedlings lost after planting
- applying silvicultural practices (thinning and pruning)
- using hired labour
- having a high level of awareness of market needs and prospects
- having a long-term commitment to balsa production
- having a broad awareness of constraints and challenges and of the potential for R&D to find suitable solutions.

Based on the information in Table 16 and from other sources, an indicative large-scale balsa grower profile was constructed. This is presented in Table 17.

Profitability estimates for a large-scale balsa grower are presented in Table 18 and Figure 21. The results indicate significantly higher NPV, IRR, AEV and return to labour compared to small-scale production and landowner group share-farming systems. For large-scale growers, balsa prices can fall to almost PGK18/m$^3$ while remaining profitable at the 20% discount rate. A key to profitability in this production system is the high balsa yield at the end of the rotation. If the year 5 yield fell to 250 m$^3$/ha and the year 3 thinning was non-commercial, then the NPV would fall by over 50% to just over PGK7,000/ha, the IRR would fall to 33% and AEV would more than halve to PGK1,137/ha/year (data not shown). Even at these yields, however, the profitability of large-scale production is superior to that of alternative production systems. These results indicate the sensitivity of balsa profitability to yield and the benefits of yield-enhancing inputs.

The pattern of cumulative discounted net cash flow for large growers, as shown in Figure 21, differs from that for smallholders and landowner grower-group production systems. This is because it is assumed that there is a commercial thinning in year 3, albeit small. The volume and quality of the logs removed determine whether it is commercial. It is assumed that thinning yields 50 m$^3$/ha and returns PGK30/m$^3$.

These results indicate the superior performance of large-scale and integrated balsa-growing systems. The better returns, however, are the result of significant additional inputs of technology and labour management. Larger operators have better control of inputs and quality of output than do small-scale operators. It is possible that even higher levels of performance can be achieved. For example, one large grower interviewed for this study advised that balsa yields of 400 m$^3$/ha had been achieved on his land. According to Howcroft (2002), potential yields from sites that are thinned at 36 months and harvested in year 5 or 6 are 450–600 m$^3$/ha. The realised yield, however, depends on several factors including site quality, general growing conditions, seed source, initial plant spacing, stocking at the time of thinning, growth rate, management and maintenance inputs and maturity (Howcroft 2002, p. 43).

Table 19 permits a comparison of some of the key results for the three production systems. By all measures at the 10% discount rate, all balsa production systems are profitable. Profitability, however, is not the only measure of success or sustainability. There are risks to sustainability with independent smallholders associated with labour supply. Under the share-farming system, the processor carries most of the risk and all of the costs. The incentive to increase yields and quality is high, but implementation requires the commitment of landowners. The large-scale production system, using high levels of technical inputs and generating high yields and quality, is most profitable. The share-farming and large-scale balsa production systems rely on hired labour.

**Table 16.** Large-scale balsa growers: key indicators

| Indicator | Status | Comment |
|---|---|---|
| Labour supply | Household and hired labour for large growers<br>Largely hired labour for integrated grower–processors | Adequate labour supply is essential for larger areas; processors who have contracts with individual growers growing >10 ha cover establishment costs |
| Source of planting material | Large and integrated growers obtain seed from their own trees or the university and propagate seedlings in their own nurseries | Productivity improvements associated with improved seedlings (from ITTO[a], Keravat source) |
| Planting rate | 1,110 seedlings/ha | Standard planting practice on a 3 m × 3 m pattern |
| Survival rate | 75–95% | Average 85%; replanting is practised |
| Thinning | Yes (all growers) | To 800–900 stems per hectare in year 2 or 3 |
| Pruning | Yes (all growers) | Prune in first 18 months to 4–5 m |
| Fertilising | No (all growers) | Some concerned about loss of vigour in third-rotation crop |
| Weeding | Yes (all growers) | Various strategies used; intensive in first year; peanuts can be grown in first year; hand weeding and slashing occur |
| Pest and disease management | No (all growers) | There is interest in control of red heart |
| Seedling cost per unit | PGK0.4 | Supplied from own nurseries; no transport costs involved |
| Source of technical information | Most relied on own resources and from the university (in Vudal) | Other growers are not an important source |
| Harvest age | 5 years | Standard practice |
| Method of selling | Standing tree | Standard practice |
| Buyer | Primary processor | Standard practice |
| Price per $m^3$ | By negotiation<br>Ranges from PGK25 to PGK50<br>Purchase agreement or supply contract | Price varies with distance from mill, quality, accessibility, scale and maturity of stand |
| Distance to processor | Ranged from 5 km to 50 km | Preference for resources closer to processing facilities; availability of suitable land is a constraint |
| Source of market information | The integrated processors get their intelligence from their customers, colleagues and the internet; large growers are not as well connected | High exposure to current and future market conditions; large growers rely on buyers being market aware |
| Knowledge of quality requirements | Very high awareness, especially of buyers' density requirements; but information generally not shared with growers | There is opportunity to strengthen growers' awareness of market needs and manage their resource accordingly, where feasible |

**Table 16.** (Cont'd) Large-scale balsa growers: key indicators

| Indicator | Status | Comment |
|---|---|---|
| Replanting intentions | All intended to replant balsa and expand their areas over the next 2–3 years | Attracted by good returns and relatively low establishment costs |
| Research and development (R&D) needs | Yes; needs include:<br>• access to improved germplasm<br>• improved kiln-drying efficiency<br>• causes and control of red heart<br>• governance<br>• silviculture<br>• inter-rotational nutrition<br>• balsa markets<br>• directional felling and chainsaw technique | Large and integrated growers are more aware of technical problems and solutions that investment in R&D can provide |
| Motivation | Strong commitment to long-term production | Diversification; good returns; supply-chain control to ensure quality and reliability of resource supply |
| Constraints | Access to good-quality seed<br>Supply of experienced and qualified employees<br>Finite, competitive market<br>High costs of labour and power<br>Scarcity of suitable land—tenure; location; condition<br>Governance<br>Infrastructure maintenance—roads<br>Inadequate incentives | Large and integrated growers are better connected along the supply chain and area able to identify industry-wide constraints |

[a] ITTO = International Tropical Timber Organization

**Table 17.** Profile of a large-scale balsa grower, East New Britain

| Key parameter | Level | Comment |
|---|---|---|
| Land preparation | 24 person-days (pd)/ha in year 1<br>10 pd/ha for second rotation | Assumes that land was previously fallow (garden)<br>Slashing using tractor |
| Planting | 25 pd/ha | Includes lining, holing and planting |
| Stocking rate | 1,110 stems/ha | 3 m × 3 m |
| Seedling survival | 85% | Based on grower feedback |

**Table 17.** (Cont'd) Profile of a large-scale balsa grower, East New Britain

| Key parameter | Level | Comment |
|---|---|---|
| Replanting | Equivalent of 388 seedlings; 2.25 pd/ha | Seedling replacement also accounts for nursery losses of 20% |
| Seedling costs | PGK0.4 per seedling | No seedling transport costs as growers obtain plants from their own nursery |
| Weeding | 44.4 pd/ha in year 1<br>None in year 2<br>Slashing 24 pd/ha year 1 followed by 4 pd/ha in years 2–5 | First and second rotations |
| Thinning | 8 pd/ha in year 2<br>8 pd/ha in year 3 | Non-commercial thinning in first 18 months<br>Potential commercial thinning in year 3 |
| Pruning | 4 pd/ha in year 1<br>2 pd/ha in year 2 | First and second rotations |
| Fertilising | None | |
| Harvesting | 2 pd/ha | Contract harvesting costs are accounted for in farm-gate price |
| Farm-gate price | By negotiation<br>PGK50/$m^3$ | |
| Yield at end of rotation | 350 $m^3$/ha | Towards high end |
| Cost of labour | PGK23.14/day | New minimum wage—first-level increase plus PGK8 labour on-costs |
| Source of labour | Hired | Adequate labour available |
| Establishment costs | PGK3314/ha | Labour represents 88% of total establishment costs (assumes that land previously fallow) |
| Maintenance costs:<br>Year 2<br>Year 3<br>Year 4<br>Year 5 | <br>PGK510.24<br>PGK323.96<br>PGK138.84<br>PGK185.12 | <br>Slashing, pruning, thinning, tending<br>Slashing, tending, thinning<br>Slashing, tending<br>Slashing, tending, harvest |

It is assumed that labour supply is adequate for these systems. There are, however, some risks to labour supply and labour management. Access to skilled employees such as electricians is also a problem for businesses in PNG. While planned increases in minimum wage rates will add to costs of production, all three models are able to continue profitably under the higher wages regime, as the return-to-labour results indicate. For some specific operations, however, the higher wage rates may lead to significant changes in the way those operations are performed. Of particular interest is the impact on balsa harvesting and transport. This is explored in the next section.

## Impact of higher wages on harvesting and transport

The biggest single component of balsa harvesting and transport costs in ENB is labour. Balsa harvesting is a labour-intensive operation. For example, one balsa processor in ENB operates a harvesting crew of around 15 persons, including 3 truck drivers. The team cuts and delivers 20 $m^3$ of balsa logs per day to the mill; a quantity that is in line with the mill's processing capacity. Current harvesting and transport costs with such a crew were estimated to be around PGK98/$m^3$, assuming that operations are year-round on a 5-days-a-week basis. This compares with actual costs of PGK90/$m^3$ cited by one processor. This cost estimate is based on the current daily minimum wage rate for unskilled workers of PGK7.44. Under the proposed new minimum wage legislation, the minimum daily wage will increase to PKG15.14 initially and then to PGK20.15. Without making any changes to the harvesting set-up, the harvesting and transport costs will increase to PGK184/$m^3$ and PGK241/$m^3$, respectively. The 171% increase in the minimum wage rate will see labour's share of harvesting and transport costs increase from around 86% currently to 94%, assuming that current levels of labour use

**Table 18.** Indicators of profitability of balsa growing for a large-scale balsa grower in East New Britain

| Measure | Baseline | Discount rate | | |
|---|---|---|---|---|
| | | 10% | 15% | 20% |
| Net present value (PGK/ha) | ≥ 0 | 14,533 | 10,455 | 7,548 |
| Internal rate of return (%) | > Discount rate | 53 | 53 | 53 |
| Annual equivalent value (PGK/ha) | > Annual returns for other land uses | 2,365 | 2,083 | 1,800 |
| Break-even farm-gate balsa price (PGK/$m^3$) | 50 | 12.49 | 15.10 | 18.1 |
| Return to labour (PGK/day) | ≥ 23.14 | 86.47 | 73.75 | 63.05 |

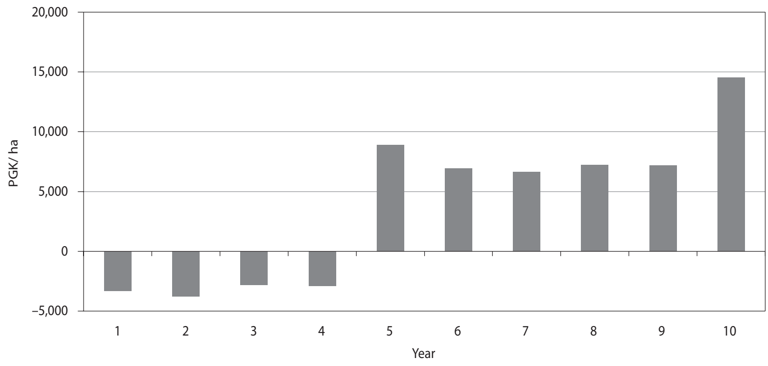


**Figure 21.** Cumulative discounted net cash flow for large-scale balsa growers at a 10% discount rate

are continued. At the higher daily wage rates and at current balsa log prices, however, present harvesting operations are unlikely to be sustained and alternative lower-cost options will be explored. The effect of the higher wage rates on harvesting and transport costs is illustrated in Figure 22.

Alternative harvesting and transport operations would be less labour-intensive and operate on a larger scale. There may be an opportunity for specialist harvesting contractors to enter the industry, although that would depend on the total area of balsa resource established and the scale of individual plantations. An option for individual growers is to harvest their resources and hire a transport contractor to deliver logs to the mill. This option may be more attractive for groups of growers close enough to each other and with a sufficient volume of logs to make it worthwhile. Individuals or groups of growers would have to invest in harvesting equipment and specialised training in tree felling to ensure efficient operations. There are, however, some potential difficulties with this option. While individual growers are likely to maximise the number of logs shipped from the forest, processors or buyers may not accept all delivered logs because of poor form or the presence of red heart or blue stain. Therefore, it would be essential that growers understand and comply with the quality requirements of the processors. This may be assured through contractual arrangements between the processor and growers as happens under the landowners' share-farming arrangement. Labour management and group coordination may challenge the success of this option. It is likely to be a more successful option for larger growers and grower groups.

As harvesting and transport costs increase due to higher wage rates and fuel costs, the option of processing logs into flitches close to the source of production using a portable sawmill or a chainsaw mill is likely to gain interest among growers and grower groups who do not have supply contracts to

**Table 19.** Profitability of balsa production systems in East New Britain at the 10% discount rate (PGK)

| Measure of profitability | Units | Independent smallholder grower | Landowner group and processor share-farming | Large-scale and integrated processor grower |
|---|---|---|---|---|
| Net present value | PGK/ha | 4,240 | 5,551 | 14,533 |
| Internal rate of return | % | 39 | 36 | 53 |
| Annual equivalent price | PGK/ha | 690 | 903 | 2,365 |
| Break-even price | PGK/m$^3$ | 13.7 | 17.21 | 12.49 |
| Return to labour | PGK/day | 45.74 | 60.41 | 86.47 |

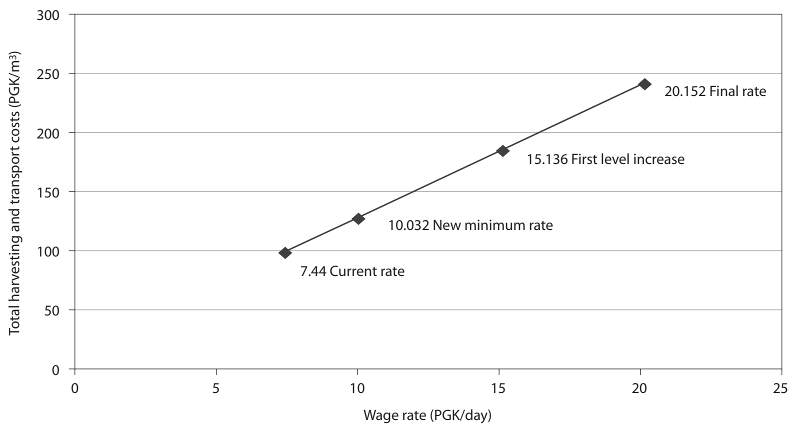


**Figure 22.** Estimated impact of increases in the minimum wage rate on harvesting and transport costs

processors. The relative costs and benefits of this option should be explored in detail in association with interested growers and processors. As noted previously, implications for resource quality and recovery should also be assessed. Smorfit et al. (2004, p. 50) concluded that chainsaw mills are wasteful of timber, require considerable manual handling of logs, have low throughput and produce rough-sawn surfaces. They suggested that mills of this type are generally suited to low-value low-volume milling or as a means of breaking down logs for further sawing. The potential use of portable sawmills in the context of rising harvesting costs and expansion of the area of balsa is worthy of further research.

As the industry shifts towards larger suppliers, including landowner groups and integrated processors, reduction of harvesting costs will be the responsibility of processors, as they control harvesting and transport. Processors will have to evaluate the financial returns of labour-saving technologies and the potential of primary sawing in the field using small-scale portable sawmills. Other options include reducing the catchment area for resource supply and concentrating on supplies within 10–15 km of the processing facilities. Identification and assessment of alternative harvesting and transport options could be included in further research into the sustained competitiveness of balsa production and processing in PNG.

# Conclusions

## General

The global balsa wood industry, estimated to trade 155,000 $m^3$ annually, was worth an estimated US$71 million in 2008. The Papua New Guinea industry (at 12,700 $m^3$, worth US$4.5 million in 2008) has made excellent progress to provide almost 8% of volume and 6% of the value of the global market.

While as a part of the overall global wood markets balsa trade may be small, the wood is used successfully as a core product in a number of advanced and innovative applications in the marine, road and rail sectors of the transport industry, and in the wind-energy industry, the aerospace industry and the defence industries. The ongoing success enjoyed by balsa is directly related to the industry's capacity to develop innovative applications.

The balsa industry in PNG is concentrated in the Gazelle Peninsula of ENB, where high-quality soils and excellent growing conditions offer a proven environment for successful growth—high-quality timber is being produced on 5-year rotations. The current plantation resource of 3,500 ha is expected to increase to 6,200 ha in 2012 and is located close to roads, processing facilities and the container port of Rabaul. Balsa produced in PNG enjoys a reputation in international markets for good quality and uniform colour and density.

Balsa cultivation is an attractive and competitive land-use option for landowners, including smallholders in ENB, providing a profitable return. Labour availability may limit the number of new growers entering the industry. Three general growing systems have emerged: individual smallholders, grower groups supplying processors under contractual, share-farming arrangements, and large landholders, including grower–processors. The industry currently provides direct employment for about 3,000 people and this will increase once the expanded plantation resource becomes productive. The capacity of the PNG industry to expand and thrive is constrained by international market demand and the industry's capacity to competitively supply these markets

While a range of technical improvements and efficiencies could increase the profitability of the balsa industry in ENB, the largest challenges are those related to maintaining competitiveness, and expanding and then maintaining the industry's niche in the international market. As PNG's current global market share by volume of 8% expands to a possible 30% in 2012, an urgent re-examination of the industry's competitive situation is needed. With reduced cocoa production and rural revenues due to cocoa pod borer, the social consequences of failure in marketing ENB balsa are potentially serious.

This study has found that the global demand for balsa appears strong and is driven by applications entailing high technology. The secondary manufacture of products containing balsa is conducted mostly in the USA, Europe, China and India, and these countries control the value chain. Global demand fluctuates with emerging projects and economic stability. For example, an increase in the number of approved wind farms can greatly increase the demand for wind turbines and balsa panels. The global economic crisis has precipitated a dramatic downturn in the recreational marine markets for pleasure craft and yachts, decreasing demand for balsa—a market reality partially responsible for the depressed demand for balsa in the USA during the first half of 2009.

Among the challenges facing balsa are:

*Competition from alternative products.* Balsa represents an entry point for those wishing to apply sandwich composite technologies. Unlike other commodities such as coffee or cocoa for which there are few substitutes, a range of balsa substitutes is available. Although end-grain balsa sheets are relatively inexpensive compared with their more expensive foam rivals, foam sheets are uniform and improving in quality.

*Competition from other growers.* Balsa is technically straightforward to grow and process. Many countries in the world have the capacity to expand their balsa production. In particular, the global balsa leader, Ecuador, has long-established networks and supply chains plus plans for a substantially expanded plantation resource. PNG has achieved a great deal in capturing 8% of the global market but it cannot be complacent and should recognise that this market share could be lost to others.

In meeting these competitive challenges, the balsa industry in ENB must address three issues that will underpin effective marketing of balsa from PNG: those of reliability, product quality and uniformity, and responsiveness. These were all raised as critical issues by industry participants.

### Reliability

Most manufacturers who use balsa have adopted 'just-in-time' supply systems for their manufacturing processes. These systems demand timely delivery to ports and locations in other countries. If delivery is not timely or reliable, clients may switch to other balsa suppliers or foam substitutes.

Reliability is dependent on an effective and efficient system of logistics from the factory gate, through road transport, ports and shipping to the client's factory. Many of the roads on the Gazelle Peninsula have deteriorated severely and this is already beginning to increase transport costs. Fortunately, the capacity of the port can reportedly accommodate increased shipments of balsa, and increased trade will improve overseas shipping schedules and lead to greater efficiency in delivering balsa from PNG to foreign ports.

A key requirement in improving and maintaining reliability is a supportive bureaucracy and the capacity of this bureaucracy to add value to the industry. A number of regulatory impediments were identified during this study, the primary one being the need for export permits issued by PNGFA. These permits are required for all wood exports under the existing legislation relating to forestry in PNG. There are no exemptions, regardless of the size of the shipment. Reportedly, it is common for these permits to take up to 4 weeks to receive Ministerial signature; the consequence of which is that orders can be cancelled or lost. Given that balsa is widely regarded by industry stakeholders as an exotic crop grown on private lands and processed by private industry with little or no government support, there appears to be a strong case for seeking an exemption for balsa from these regulations. While customs, quarantine and other export procedures were not raised as frequently as the issue of export permits, it is uncertain if government agencies possess the capacity to service an expanded flow of exports, such as 146 containers per month.

### Product quality and uniformity

Balsa is being used in increasingly high-technology applications where performance to specifications is critical. Manufacturers need high-quality and uniform materials to produce products within design specifications. The quality issues raised through this study included uniformity of density within end-grain sheets, colour and moisture content. Technical improvements to growing and processing balsa will add considerably to product uniformity and include genetics, silviculture, sawing, drying and gluing of end-grain blocks. Establishment of clear industry standards for balsa will assist in creating a market brand for balsa from ENB.

### Responsiveness

The global markets for balsa are volatile and respond to emerging projects that use balsa in areas such as wind energy, railway rolling stock and defence applications. In addition, changing international financial conditions affect demand for balsa. To maintain its small but significant share of the global market, the balsa industry in PNG should aim to develop a reputation for responsiveness. The capacity to respond positively and promptly to requests will be enhanced through coordinating and synchronising balsa supply with balsa-processing needs and with the changing demands in international markets.

## Marketing

There is little doubt that balsa can be successfully grown and processed in ENB. As production increases, effective marketing will be essential to expand and maintain its niche in the international market in the face of competition from the market leaders in Ecuador. Supported by a strong PNG market reputation for reliability, product quality and responsiveness, exports can be expanded in the emerging markets of China and India that are relatively close to PNG. In environmentally sensitive industries such as the wind-energy sector, there is some attraction in certifying sources of balsa plantation wood and ensuring that effective chains of custody are maintained. The renewable and recyclable nature of balsa offers it strong environmental credentials in competitive markets.

Apart from its proximity to emerging markets in Asia, PNG has many attractions as a global supplier of high-quality balsa. The ENB industry now has international experience and market contacts. For companies with dual-source supply policies, it offers a reliable alternative to supplier companies based in Ecuador. The political and fiscal instability that has plagued Ecuador in recent years is regarded as a risk to business and several manufacturers, particularly those in China, seek to foster alternative sources of supply.

ENB is fortunate in having the services of NARI LAES, one of the longest-standing agricultural research stations in the Pacific. In addition, the skills available to the balsa industry at the PNG University of Natural Resources and Environment (UNRE, in Vudal) offer an opportunity for ongoing technical support.

## Opportunities for research and development

An expanding and competitive, profitable, export-oriented balsa industry in ENB offers many opportunities along all parts of the value chain for R&D input.

### Growing balsa

Growing high-quality balsa sustainably and productively in managed plantations presents a series of R&D issues, among which are:

*Breeding.* The consequences of poor-quality germplasm are evident in the existing plantation base. There is an opportunity to apply genetic selection and breeding to increase growth rates, improve stem form and reduce branchiness, select for wood density and disease resistance and build upon the foundations left by the ITTO Project. In particular, such work should follow up the SPC FACT Project that seeks to establish a balsa tree improvement program with one of its member companies in ENB.

*Silviculture.* Basic studies of silviculture, such as initial spacing, thinning and pruning, management across multiple rotations (natural regeneration, debris management) and nutrient management offer an opportunity for involvement of UNRE at Vudal.

*Inventory.* There are few accurate data on the extent of the balsa resource in ENB; most area figures are educated estimates only. Successful management of an internationally competitive industry requires accurate estimates of the extent, age classes and growth rates of the resource base. There is an opportunity to review the volume tables currently being used and to use satellite imagery to manage smallholder resources.

*Pests and diseases.* The potential of pests and diseases to threaten the balsa industry is a risk. While several stakeholders in the industry recognised the risks, none of the growers interviewed for this study had a deliberate disease and pest management strategy. Knowledge of extant and potential pests and diseases of balsa is scant. An understanding of the causal agents or the physiological reasons for the premature formation of red heart—high-density heartwood—would assist in management and volume recovery from plantations.

*Managing site fertility under repeated cropping.* Growers have expressed concerns at possible site nutrient depletion after several rotations. Some sites in ENB are now supporting their fourth rotation. The long-term impacts of tree cropping on the soils of ENB are not well understood.

*Certification of plantations.* Most modern plantations seek certification through one of the existing certification schemes. Such certification offers a competitive advantage where products are used in environmentally sensitive industries. Either individually or as a group, the plantations of the Gazelle Peninsula have the potential to be certified, which would unify management standards and improve market prospects in environmentally sensitive sectors such as the wind industry. To complement plantation certification, chain-of-custody procedures could be established for the processing of the balsa wood.

*The balsa manual*, published in 2002 (Howcroft 2002), has provided an excellent foundation for balsa growers in ENB. Since its publication, the industry has grown substantially and a great deal of new knowledge has become available. A new edition of the manual could be written and made available electronically.

### Harvesting and haulage

Those responsible for harvesting and haulage have obligations to the grower to maximise merchantable volume removed (and enhance stumpages) and to maintain the quality of logs delivered to the mill (to improve recoveries). These operations are subject to close scrutiny by growers and joint-venture partners as the merchantable logs provide the financial return for 5 years of plantation management.

*Log measurement and recording*

Once the ENB resource reaches production levels based upon a 6,200 ha estate, it is likely that over 6,000 logs will be harvested and processed daily. Accurate measurement and recording of logs removed from a site is a vital part of the business chain. Practical considerations suggest that this is logically conducted in the controlled conditions of the mill, but this requires consensus and established trust with the grower. For the benefit of all growers and processors, there is a need to adopt an agreed uniform approach to avoid confusion. The assessment of a range of options, with the view that the industry could accept a process that enjoys a consensus of support, is required.

*Directional felling.*

Reports indicate that directional falling is an issue, with breakage (and loss of merchantable volume) being common. PNG possesses some excellent training facilities for the logging industries (including directional felling), and better training would offer much to the industry.

*Improving recoveries*

Industry might consider adopting uniform log-grading rules that best accommodate the need for high-quality logs for the mills and the need to maximise recoveries of merchantable wood from the plantation.

## Primary processing

*In-field processing*

Experience in Ecuador suggests that in-field processing of balsa logs using portable sawmills can be economically attractive. In-field production of rough-sawn flitches can reduce transport costs and avoid problems of disposal of off-cuts at the main processing plant. Portable sawmills, however, are notoriously inefficient in terms of sawn-wood recovery, more so if equipment is not correctly maintained or the operators are not well trained. The logistics of managing staff and equipment for a portable sawmill offer some challenges that require assessment.

*Log segregation*

One of the major considerations in balsa processing is wood density; most major processors segregate their product into three density classes. Early log segregation on the basis of density would offer efficiencies and cost savings in processing; measuring and managing stiffness can increase profits and log recoveries. We suggest that some of the sonic technologies such as Hitman could be assessed (for example, see Dickson et al. 2005). These technologies could also be adapted to segregate boards into density classes at later stages of processing.

*Sawing*

Growth stresses in balsa and the presence of an irregular, wandering pith challenge accurate and efficient sawing. Sawn-wood recovery might be improved through the adoption of alternative sawing patterns designed to reduce losses from growth stress.

*Drying*

Kiln-drying is an essential and expensive part of balsa processing as most markets require wood with a moisture content of 12%. Higher moisture contents can compromise the curing of resins and adhesives used in later manufacturing processes. Although there are several drying schedules available for balsa, it would be useful to assess the applicability and cost-effectiveness of emerging solar-based kiln-drying systems. The ambient humidity in ENB is constantly high and new approaches that slow moisture re-absorption following kiln-drying would offer efficiency and cost savings.

## Secondary manufacture and product development

Any expanded use of balsa in sandwich composites could include a broader range of skin materials, giving rise to the challenge of delamination—the loss of adhesion between the composite skin and the balsa. This is a significant problem (for example) where design specifications for a wind-turbine blade could require a service life of 25 years. A clearer understanding of the parameters or variables that underlie delamination of balsa products, particularly those wood parameters that might affect resin curing and durability, would help to increase the range of applications for balsa.

## Integrating balsa growing and processing with the community and extension services

Issues surrounding transparency, communication and trust were the concerns most commonly raised during interviews with growers and processors. As the nature of ownership of the plantation resource has changed since 2002 from predominantly smallholders to groups of small landowners pooling resources to develop plantations, the needs for communication have changed. In the absence of an impartial forum for discussion among growers and between growers and processors, much balsa-related technical information and market intelligence is based upon gossip and subject to misinterpretation. There is a need for a forum where good-quality information on markets, silviculture and prices can be shared and grievances regarding stumpages, measurement and wastage aired.

There is a role for an active and impartial referee who could sympathetically mediate in disagreements between landholders, growers and processors.

Options for the most appropriate avenue to offer such support to a balsa group, perhaps under the auspices of the PNG Growers' Association, need to be explored. Such a group could offer newsletters, brochures and manuals, coordinate regular meetings and ensure extension services and technical support are available. Among the extension services required are deployment of improved germplasm and provision of technical information on growing balsa and on markets.

## Social and environmental issues

Although time and resources limited this study, a number of cross-cutting issues were identified that require further examination. Included among these are issues of gender and decision-making in the balsa business, and women in the context of a matrilineal society and use of land to grow balsa.

The assessment of the profitability of balsa-growing identified some important areas that would benefit from further research and lead to improvements in productivity and performance of the balsa industry in ENB. These include:

- the potential for expansion of balsa production in ENB in the context of cocoa pod borer and the withdrawal of land from cocoa production—what growers' land-use intentions are; what the limiting factors to balsa expansion are—adequate labour supply, access to suitable land with workable tenure and within economic reach of processors, the pattern of international market demand for balsa and PNG's international competitiveness[11]
- household labour-management strategies for smallholder balsa production
- harnessing the potential role of grower groups in the supply of balsa resources and strengthening grower-group capacity through improvements in governance, technology transfer, information dissemination, financial services, maintenance of quality standards and other market requirements, and contract negotiation
- assessment of management options for different balsa production systems in the context of rising labour costs and higher prices for other key inputs, including electricity—for example, the prospect of a more capital-intensive balsa industry in ENB.

The option to grow balsa profitably has offered prospects to those with interests in small plantations and who have been burdened with mortgage debt from plantation purchase schemes. The magnitude of this as a motivating factor in establishing balsa plantations was substantial but unclear and deserves study.

Further research might begin with a major baseline survey of the balsa industry in ENB covering all grower and processing systems and relations between growers and processors. The method of analysis used in this current assessment of profitability was unable to simultaneously evaluate the potential of competing and complementary land uses. Further research would benefit from the use of farm models incorporating alternative land-use options and subject to resource constraints that are typical for the different land-use systems. This type of analysis would provide a strong base for establishing growth prospects of the balsa industry in ENB.

No clear impacts on the environment were noted.

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11 In the course of this study, financial data were obtained for balsa production in Ecuador and Peru that could be used in further analysis of the international competitiveness of PNG balsa.

## Governance and standards relating to balsa

The nature of the balsa industry has changed over recent years. The appropriateness of existing forestry legislation and regulations for a relatively small and distinct industry (US$4.5 million compared to PNG's larger log export sector of US$170 million) based upon an exotic plantation tree repeatedly cropped on 5-year cycles needs to be transparently examined. The capacity of PNGFA to offer a full suite of extension services is limited and appropriate technical skills within the organisation appear to have been eroded. An analysis of governance issues surrounding the balsa industry would include:

- changes to, or exemptions from, the forestry legislation that might be appropriate to facilitate improved market flexibility for the balsa industry, maintain competiveness and reduce costs of regulation
- the role for government in the balsa industry and an impartial examination of where and how it can add value
- the logical role for the agriculture sector in the balsa industry and the most appropriate avenue for R&D support in ENB
- a review of the balsa industry's draft 'Code of practice' before considering certification.

## Marketing

If PNG is to maintain and expand its niche in global balsa markets, it will need a system of marketing support that will help identify new markets and emerging applications for balsa and capitalise on PNG's reputation for reliability, product quality and responsiveness. A system of market support would clarify issues surrounding world demand and help define the potential size of the PNG global share. Such information could usefully lead to the identification of the capacity of ENB to provide balsa and of limitations to expansion, and help address the challenge of synchronising production of balsa wood with processing capacity and market demands. A system of market support would be linked with studies leading to certification of the ENB balsa resource.

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# Appendixes

# Appendix 1: Papua New Guinea balsa log grading rules

## The PNG Balsa Company

### *Balsa log preparation and grading*

#### Preparation

Trees will be felled in a workmanlike manner to avoid felling damage
Trees must be cut within 30 cm of the ground
Crosscutting will be at right angles to the stem both horizontally and vertically
Logs must be fresh cut and debarked with no blue stain or insect attack

#### 1. Standard length

The standard length of billets is 1.8 m, however a few pieces can be accepted in 10 cm decrements down to a minimum of 1.3 m. Measurement is recorded to the closest lower 10 cm multiples.

#### 2. Diameter

The minimum diameter is 17 cm under bark and there is no maximum diameter. Measurement is to the closest lower centimetre.

#### 3. Bends and sweep

Small logs up to 30 cm diameter—maximum deviation from central axis 20 mm
Logs 30–40 cm diameter—maximum deviation from the central axis 40 mm
Logs above 40 cm diameter—maximum of 60 mm deviation acceptable

#### 4. Red heart and heart rot

Logs from 17 to 30 cm allow maximum of 40 mm diameter of red heart
Logs from 31 to 40 cm allow maximum of 100 mm diameter of red heart
Logs greater than 40 cm must have 150 mm of usable white wood

#### 5. Branches and knots

Logs 20–30 cm diam.Two branches or sound knots allowed up to 30 mm diameter
Logs 31–40 cm diam.Allow two branches or sound knots up to 50 mm diameter
Logs 41cm and greater diam.Allow two branches or sound knots up to 100 mm diameter
Branches must be cut off cleanly, level with the surface of the log
Knots and branches with internal defect are not allowed

#### 6. Blue stain

No blue stain to be allowed

#### 7. Dead and dry wood

Wood in dead trees allowable if recently dead with no blue stain or insect attack

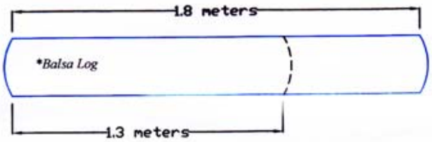
#### 8. Heavy wood

Heavy wood not allowed

# BALSA BILLET SPECIFICATION

**REVISED EDITION II - 060709**

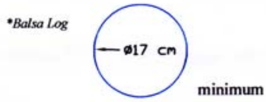
## 1. Length




STANDARD LENGTH 1.8 METER

- maximum length 1.8 m
  minimum length 1.3 m

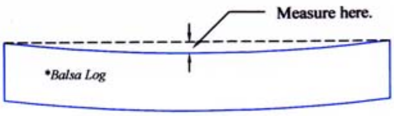
## 2. Diameter




- minimum 17 cm under bark
  maximum - No limit

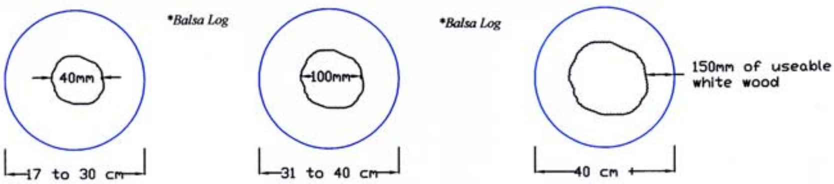
## 3. End Cutting


## 4. Bend



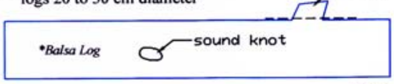

- Diameter 17 - 30 cm - allow 20mm
  Diameter 30 - 40 cm - allow 40mm
  Diameter 40 cm + - allow 60mm

## 5. Red Heart



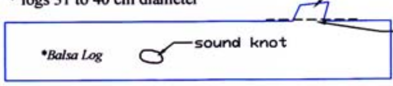

## 6. Branch Knot

* logs 20 to 30 cm diameter



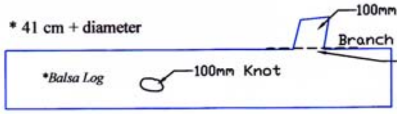

* Two branches or sound knots allowed up to 30mm dia.

* logs 31 to 40 cm diameter




* Cut branch level with log.
  Allow 2 branches or sound knots up to 50mm diam.

* 41 cm + diameter




* Cut branch level with log.
  Allow 2 branches or sound knots up to 100mm diam.

*07th July 2009*

# Appendix 2: United States of America balsa imports

**Global and ex-Ecuador, 1999–2008 (Source: US Trade Statistics, United States Department of Agriculture (USDA) Foreign Agricultural Service (FAS))**

| Source | HTS No. | Description | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global | 440724005 ($m^3$) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness over 6 mm, rough | 227 | 468 | 167 | 417 | 392 | 311 | 512 | 24 | 0 | 0 |
| Global | 440724006 ($m^3$) | Balsa wood, sawn/chipped lengthwise, greater 6 mm thick | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35,196 | 0 | 0 |
| Global | 440724010 ($m^3$) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm, NESOI[a] | 13,495 | 11,080 | 8,881 | 8,306 | 13,872 | 77,870 | 65,385 | 35,736 | 0 | 0 |
| Global | 4407220006 ($m^3$) | HW lumber balsa No. cubic metres balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 71,798 | 78,545 |
| Global | Total Balsa ($m^3$) | | 13,722 | 11,548 | 9,048 | 8,723 | 14,264 | 78,181 | 65,897 | 70,956 | 71,798 | 78,545 |
| Global | 440724005 (US$ ’000) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness over 6 mm, rough | 139 | 94 | 37 | 298 | 191 | 140 | 211 | 16 | 0 | 0 |
| Global | 440724006 (US$ ’000) | Balsa wood, sawn/chipped lengthwise, greater than 6 mm thick | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13,986 | 0 | 0 |
| Global | 440724010 (US$ ’000) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm, NESOI [a] | 3,924 | 3,049 | 2,399 | 2,095 | 4,344 | 25,638 | 23,583 | 13,942 | 0 | 0 |
| Global | 4407220006 (US$ ’000) | HW lumber balsa No. cubic metres balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30,990 | 36,358 |
| Global | Total balsa (US$ ’000) | | 4,063 | 3,143 | 2,436 | 2,393 | 4,535 | 25,778 | 23,794 | 27,944 | 30,990 | 36,358 |
| | Average global price (US$/$m^3$) | | 296 | 272 | 269 | 274 | 318 | 330 | 361 | 394 | 432 | 463 |

| Source | HTS No. | Description | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ecuador | 440724005 ($m^3$) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness over 6 mm, rough | 112 | 57 | 147 | 128 | 184 | 293 | 249 | 24 | 0 | 0 |
| Ecuador | 440724006 ($m^3$) | Balsa wood, sawn/chipped lengthwise, greater than 6 mm thick | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35,007 | 0 | 0 |
| Ecuador | 440724010 ($m^3$) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm, NESOI [a] | 13,133 | 9,870 | 7,872 | 7,797 | 13,297 | 77,350 | 64,963 | 33,799 | 0 | 0 |
| Ecuador | 4407220006 ($m^3$) | HW lumber balsa No. cubic metres balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 71,038 | 73,611 |
| Ecuador | Total balsa ($m^3$) | | 13,245 | 9,927 | 8,019 | 7,925 | 13,481 | 77,643 | 65,212 | 68,830 | 71,038 | 73,611 |
| Ecuador | 440724005 (US$ '000) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness over 6 mm, rough | 37 | 48 | 23 | 52 | 56 | 133 | 93 | 16 | 0 | 0 |
| Ecuador | 440724006 (US$ '000) | Balsa wood, sawn/chipped lengthwise, greater than 6 mm thick | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13,894 | 0 | 0 |
| Ecuador | 440724010 (US$ '000) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm, NESOI [a] | 3,788 | 2,785 | 2,154 | 1,871 | 4,038 | 25,380 | 23,505 | 13,607 | 0 | 0 |
| Ecuador | 4407220006 (US$ '000) | HW lumber balsa No. cubic metres balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30,534 | 34,964 |
| Ecuador | Total balsa (US$ '000) | | 3,825 | 2,833 | 2,177 | 1,923 | 4,094 | 25,513 | 23,598 | 27,517 | 30,534 | 34,964 |
| | Average Ecuador price (US$/$m^3$) | | 289 | 285 | 271 | 243 | 304 | 329 | 362 | 400 | 430 | 475 |

| Source | HTS No. | Description | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CIF[b] ex Ecuador | 440724005 (US$ '000) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness over 6 mm, rough | 37 | 48 | 23 | 52 | 56 | 133 | 93 | 16 | 0 | 0 |
| CIF[b] ex Ecuador | 440724006 (US$ '000) | Balsa wood, sawn/chipped lengthwise, greater than 6 mm thick | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13,894 | 0 | 0 |
| CIF[b] ex Ecuador | 440724010 (US$ '000) | Balsa wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm, NESOI [a] | 4,204 | 3,132 | 2,419 | 2,091 | 4,357 | 28,012 | 25,875 | 14,647 | 0 | 0 |
| CIF[b] ex Ecuador | 4407220006 (US$ '000) | HW lumber balsa No. cubic metres balsa wood, sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31,881 | 37,412 |
| CIF[b] ex Ecuador | Total balsa (US$ '000) | | 4,241 | 3,180 | 2,442 | 2,143 | 4,413 | 28,145 | 25,968 | 28,557 | 31,881 | 37,412 |
| | | Implied insurance and freight costs (CIF minus import value) | 416 | 347 | 265 | 220 | 319 | 2,632 | 2,370 | 1,040 | 1,347 | 2,448 |
| | | No. of containers (assuming 28 $m^3$ = 1 container) | 473 | 355 | 286 | 283 | 481 | 2,773 | 2,329 | 2,458 | 2,537 | 2,629 |
| | | Implied cost per container shipment Ecuador – USA | 879 | 979 | 925 | 777 | 663 | 949 | 1,018 | 423 | 531 | 931 |

[a] NESOI = Not elsewhere specified or included
[b] CIF = cost insurance freight
HW = hardwood
HTS = 'Harmonized System Codes' of the World Customs Organization for imports

# Appendix 3: Balsa purchasing agreement form

**BALSA PURCHASING AGREEMENT** 09900

Name of Grower: ..........................................................................

I, Purchaser: ..........................................................................

agree to pay the above Grower at the rate of K .............................. per cubic metre

for balsawood from his block / plantation at ..........................................................................

..........................................................................

Signed: ..........................................................................
*Purchaser / Agent*

Signed: ..........................................................................
*Grower*

*Location:* ..........................................................................

*Grower's Address:* ..........................................................................

*Date:* ............ / ............ / ............

*All monies due to the Grower will be paid by the purchaser to the Forestry Department within one month of receipt of the timber.*

Signed .......................................................................... Date: ............ / ............ / ............
*Purchaser / Agent*

In default of payment Forestry Department will stop any further exports until payment is met.

The grower will present this form to the Forestry Department as soon as possible after the balsa has been cut and delivered to the mill.

PNG PRINTING KOKOPO

# Appendix 4: Balsa log tally sheet