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Opportunities for the smallholder sandalwood industry in Vanuatu

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Tony Page, Hanington Tate, Colin Bunt, Anna Potrawiak and Alick Berry

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Cover: Vanuatu Department of Forests nursery technicians Paul Thomas and Donald Tala are working with Mr Willie Lava and his family to promote appropriate practice in sandalwood planting, as part of an ACIAR-funded project. (Photo: Hanington Tate)

Foreword

Over the past 30 years, the Australian Centre for International Agricultural Research (ACIAR) has been investing in collaborative forestry research in the South Pacific region. Forests and trees are of great importance to the livelihoods of communities in many Pacific countries. The forestry sector across the South Pacific region is quite diverse, and the research issues and capacity vary greatly between countries. ACIAR's forestry research program focuses largely on planted forests, improving germplasm, enhancing agroforestry and improving value chains for wood and non-timber forest products. Research is being conducted to support the policy base for sandalwood and to enhance the availability of high oil-yielding sandalwood trees.

Species of sandalwood are native to India, Indonesia, Papua New Guinea, Australia and Pacific island nations, including Vanuatu. Sandalwood is one of the world's most valuable forest products. It is a hemiparasite, with the tree gaining water and nutrients from the host plant. Sandalwood trees produce oil-rich fragrant heartwood, from which the oil is distilled for use in perfumes, or which is powdered for use in incense products. Much of the wild-sourced sandalwood has been overharvested around the world, often with limited attempts at natural regeneration or replanting. Only Australia has moved towards establishing sandalwood plantations. As international volumes of sandalwood have declined, its price has steadily increased over the past few decades.

Vanuatu's largely rural population has limited capacity to improve livelihoods, due to the very small cash economy and limited infrastructure. High-value, low-volume products offer the greatest opportunities for improving rural livelihoods. Vanuatu first exported sandalwood during the mid 1800s. Since the mid 1990s, the Vanuatu Government has been implementing measures to foster the sustainable use of sandalwood. These include controlling the quantity that can be harvested, requiring value-added processing within Vanuatu and producing sandalwood seedlings for planting by landowners. The money earned by landowners from sandalwood has enabled them to access healthcare and education services, and resulted in additional interest in planting sandalwood across the country.

This report discusses the current rate and location of new plantings in Vanuatu, as well as the silvicultural requirements for growing sandalwood. Data from existing plantings form the basis for determining likely economic returns expected for smallholders and other investors from growing sandalwood. Important marketing and policy considerations are identified to optimise the value and sustainability

of the Vanuatu sandalwood industry. The information presented here will be of benefit to policymakers, processors, exporters, investors and smallholder farmers, as well as donor agencies, and will help ensure that the Vanuatu sandalwood industry has a bright future.

Nick Austin
Chief Executive Officer
ACIAR

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Abbreviations

BCR	benefit:cost ratio	**m**	metre
cm	centimetre	**m^3**	cubic metre
ha	hectare	**NPV**	net present value
IRR	internal rate of return	**VDoF**	Vanuatu Department of Forests
kg	kilogram		
km	kilometre	**vt**	vatu

Currency (as at 2 August 2008)

US$1 = 101.17 vatu
A$1 = US$0.93
100 vatu = A$0.89

Acknowledgments

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This publication is dedicated to the memories of Atchinson Smith and Tarere Karae, both foresters with the Vanuatu Department of Forests who made valuable contributions to the research and development of forestry in Vanuatu. They were both highly regarded members of the department who unexpectedly lost their lives in 2009 and are greatly missed.

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Summary

Vanuatu is a developing country with a small rural-based economy and limited high-value export products. It has a wealth of forest resources that provide benefits to local communities on both subsistence and commercial levels. Timber exports from Vanuatu have been a good source of foreign exchange, royalties and taxes. However, timber volumes have decreased over the past 10 years, reducing potential export earnings and royalties available to the Vanuatu Government. A positive outcome of this decline is that it has led to increased community and private interest in producing commercially significant forestry species, particularly the highly valuable sandalwood tree.

Sandalwood (*Santalum* spp.) provides high-value, low-volume, non-perishable products that are in demand on the international market. Although only small volumes are harvested from wild sources in Vanuatu (80–120 tonnes annually, representing ~1–2% of world supply), it has contributed significant export revenue and provided a significant proportion of income to harvesters.

Wild-harvested sandalwood is the basis of the worldwide sandalwood industry, and most countries have severely depleted their natural reserves. This downward supply trend, combined with continued demand, has resulted in sustained price increases on the international market and has prompted interest in commercial plantings of sandalwood.

Although sandalwood has been traded internationally for several centuries, plantations have only been established in the past 20 years. In Vanuatu, this has resulted in the establishment of between 270 and 550 ha of smallholder plantings and 150 ha of commercial plantings since 2000.

This report describes the current activities of smallholder and commercial producers in establishing new sandalwood plantings. Basic information is provided on expected growth rates, heartwood development and length of rotations for sandalwood plantings. A market overview and recommendations for further development of the industry are provided. Policy issues and recommendations are discussed to facilitate greater investment and control over the marketing of the products at harvest.

In Vanuatu, sandalwood plantings can be readily incorporated into existing swidden agriculture, and village and boundary plantings. Reliable methods and information now exist for establishing and maintaining sandalwood in smallholder and commercial plantings. However, more resources are needed to ensure that new participants can implement appropriate silvicultural practices. For example, the pruning of young sandalwood trees to promote the formation of trees with a single bole can increase the value of the tree by encouraging greater heartwood development from the root to the branches, and improving the possibility of attaining a high-value carving log. If this simple management practice is adopted more widely, it has the potential to add significant value to Vanuatu's planted resource and its future exports.

It appears that a 15–20 year rotation may be reasonable for trees growing on optimal sites. However, much longer rotations (30 years or more) may be expected when establishing sandalwood on suboptimal sites. Despite this, smallholder sandalwood production in Vanuatu is economically feasible, with an internal rate of return of 24% for sandalwood agroforestry. A sandalwood agroforest harvested for heartwood has a net present value that is approximately 13.5 times swidden cropping. This study also demonstrated that the production of sandalwood on a shorter rotation for sapwood is not economically competitive with sandalwood agroforestry at both 15 and 30 years. The return to labour for sapwood production was less than the current minimum wage. In contrast, a 1 ha sandalwood agroforestry planting harvested for heartwood at 15–20 years returns the equivalent income to that of a Vanuatu Government employee with a technical college diploma. The earnings for sandalwood agroforestry are much greater than many smallholders can expect to earn from other activities or employment.

A high potential exists for further investment in planting sandalwood in Vanuatu. Vanuatu has

a relatively stable political, business and social environment, suitable land for growing sandalwood, improving infrastructure in some of the more developed islands, and improved germplasm resource becoming available with current Australian Centre for International Agricultural Research investments. Further investment in establishing new sandalwood plantings, undertaken either individually or in partnership with a custom landowner, is encouraged by the Vanuatu Government since it can help to improve the development of the industry, create new employment opportunities and increase the future export earning capacity of the country. National policy changes relating to security of tenure over plantations and rights to market are required to facilitate greater investor interest and maximise the potential value of the industry.

The future prospects for the Vanuatu sandalwood industry can be improved by:

- developing a niche market for Vanuatu sandalwood with a focus on developing strong supply-chain relationships in one or two appropriately sized, premium markets
- establishing a peak industry body (formal or informal) to facilitate greater cohesion among participants and improve planning and coordination in meeting market demands
- developing an industry development strategy recognising commercially confidential information and focusing on areas of common interest, such as improving export supply chains, developing industry standards and prioritising research and development needs
- developing certification programs and product standards to develop a clear 'brand' identity for Vanuatu sandalwood
- increasing the availability of high-quality planting stock and improving silvicultural management in existing and future plantings.

This report clearly demonstrates the economic feasibility of producing sandalwood on a smallholder basis in Vanuatu. The future for sandalwood production in Vanuatu is very bright, with high and increasing levels of planting across many isolated areas of the country ultimately leading to greater export volumes, resulting in improved balance of trade, government tax revenues, local economic activity and smallholder livelihoods.

Introduction

Sandalwood (*Santalum* spp.) comprises 16 species distributed across India, Indonesia, Papua New Guinea, Oceania and Australia (Applegate et al. 1990; Harbaugh and Baldwin 2007). Sandalwood trees are highly valued for their fragrant heartwood oil, which has been used for centuries for religious and customary purposes, and is still used for cosmetics, aromatherapy and perfumery (Yusuf 1999). The heartwood is also used for ornamental or ceremonial carvings, or powdered for the manufacture of incense and other products valued in the international agarbatti market (Doran and Brophy 2005). Seven species are currently used commercially, but the high demand for sandalwood products and the lack of commercially produced sandalwood have culminated in a sharp decline in the natural supplies of many species (Bulai 2007; Butaud and Mallet 2007; Rimbawanto and Haryjanto 2007; IUCN 2009).

Santalum austrocaledonicum is indigenous to New Caledonia and Vanuatu, and is commercially important in both countries. In Vanuatu, sandalwood harvesting is the primary source of income in many villages and supports both rural and urban employment. The harvest of sandalwood from natural stands was the first export industry in Vanuatu, commencing in the 1820s, and continues to be a major source of export revenue. Currently, there are two sandalwood oil distilleries in Vanuatu that buy wild-harvested wood from custom landowners and export both raw and processed product (Lui and Smith 2007). This, however, has involved extractive harvesting from natural stands, which has led to a serious reduction in the wild resources (Gillieson et al. 2008). The species is known to be amenable to agroforestry production (Corrigan et al. 2000), which, if widely adopted by rural communities, could alleviate harvesting pressures on wild stands while developing an economically significant smallholder industry.

The aims of this study were to:

- determine the extent of sandalwood plantings and identify opportunities and constraints for its further development
- determine the feasibility and profitability of the sandalwood plantation industry to smallholders and other participants
- evaluate alternative strategies for financing planting activities by smallholders
- present marketing options for sandalwood, including sapwood by-products
- define government policy initiatives to facilitate the development of the industry
- define a promotion strategy and information package for current and potential growers and investors.

Sandalwood and its uses

Biology

Vanuatu sandalwood trees are generally small to medium-sized (5–10 m) trees that occur on dry slopes of the western parts of several islands. Like all sandalwood species, it is also hemiparasitic, with its roots forming haustorial connections with the roots of other plants known as hosts (Tennakoon et al. 1997; Tennakoon and Cameron 2006). The sandalwood tree draws part of its water and nutrient requirements from its hosts through these connections. Flowering occurs twice annually, typically alternating between a heavy and light crop. The flowers are small, white and borne in panicles, and produce single-seeded, fleshy fruits (7–20 mm × 10–15 mm) (Thomson 2006). These fruits turn purple/black in colour at maturity and are consumed and dispersed by birds. The trees are long lived, attaining ages of over 50 years, but due to harvesting pressures it is now rare to find trees over 30 years old. Heartwood development varies between trees and is influenced by the growing environment. Under suitable growing conditions, heartwood can begin developing before trees are 10 years old, and produce modest commercial quantities after 15–20 years. The species has few pests and diseases except for brown root rot (*Phellinus noxius*), which is a particular problem when trees are grown in wet or poorly drained sites.

Uses

Aromatic oils produced in the heartwood and roots of sandalwood trees are one of the world's most valuable tree products. Sandalwood has significant cultural importance in many parts of Asia, where many Hindus, Bhuddists, Chinese and Muslims have used the oil and burnt the wood during ceremonies for centuries (Yusuf 1999). The major consumer end uses of sandalwood in eastern markets include handicrafts and carving, non-alcoholic fragrances, toiletries, mouth freshener, medicinal uses, incense and as a flavouring agent (Thomson 2008). Sandalwood is also valued in western societies where it features as a key ingredient in perfumes and in other value-added products such as incense, toiletries, cosmetics and aromatherapy (AAG 2006).

Regardless of the sandalwood species, the three main trading products are carving logs, oil and powder. Carving logs are the highest value sandalwood product and are typically defined as straight pieces of heartwood with a clear grain, no cracks or faults and a minimum of 10 cm diameter at their smallest end. The length can vary from a minimum of 30 cm to a maximum of 120 cm.

Sandalwood oil is extracted commercially through steam distillation of chipped heartwood, typically from logs that have elevated levels of santalol and that are therefore considered to have a superior fragrance. The oil is an important component in perfumery, as it has both an attractive and a persistent fragrance with a superior capacity to fix and blend other fragrances (Yusuf 1999). The production of a traditional attar in India involves the infusion of floral essences into a base of sandalwood oil, where the fixative properties of the sandalwood bind with the delicate floral oils and improve and increase the longevity of the floral fragrance.

The final sandalwood products used in burning for their fragrance are collectively known as agarbatti. In India, sandalwood has been used extensively in funeral pyres, but, due to its scarcity and high price, only token pieces of sandalwood (usually *S. spicatum*) are currently used for this purpose. Currently, most of the lower quality heartwood is powdered and processed as incense for burning.

Production

Seven species are currently used commercially: *S. album* (India and Indonesia), *S. austrocaledonicum* (New Caledonia and Vanuatu), *S. insulare* (Cook Islands and French Polynesia), *S. lanceolatum* (Queensland, Australia), *S. macgregorii* (Papua New Guinea), *S. spicatum* (Western Australia) and *S. yasi*

(Fiji, Samoa and Tonga). The uncontrolled harvesting of four sandalwood species in Hawaii (*S. ellipticum*, *S. freycinetianum*, *S. haleakalae* and *S. paniculatum*) during the early 1800s depleted the available wood, and only recently are these species beginning to support a commercial trade. Overexploitation of natural sandalwood stands has severely reduced the supply of its products; consequently, people across a number of countries have begun to plant sandalwood in plantations or within their normal garden/cropping systems.

Interestingly, despite centuries of sandalwood trade in all commercial species, the sandalwood plantation sector has only emerged in the past 20 years (Radomiljac 1998; Radomiljac et al. 1998). The late development of this sector is possibly due to a poor understanding of the hemiparasitic nature of sandalwood and host requirements, and the subsequent failure of pure plantings (Rai 1990; Butaud and Mallet 2007).

The most substantial plantings of sandalwood exist in Western Australia where *S. spicatum* and *S. album* have been planted. Sandalwood planting in other countries has been limited for various reasons, including sandalwood's long-term rotation, restrictive government policies regarding harvesting rights and the high level of competition for the use of land for food production (e.g. in India), the higher prices paid for other timber species (e.g. eaglewood in Papua New Guinea) (Bosimbi and Bewang 2007) and the impact of natural phenomena (e.g. high fire frequency in New Caledonia in areas of the natural distribution of *S. austrocaledonicum*; Tassin et al. 2007).

Indian sandalwood (*Santalum album*)

Indian sandalwood is native to India, Indonesia and northern Australia, and is considered the most valuable species given its historically high heartwood oil concentrations of α- and β-santalol. Currently, native resources of *S. album* in India account for approximately 95% of total global production (Adviser Edge 2008).

India has traditionally been the world's main source of high-quality *S. album*, but the supply has declined over the past 10–15 years (Adviser Edge 2008; Burfield 2009), reportedly due to illegal harvesting and the prevalence of spike disease (McKinnell 2008). Spike disease is a mycoplasma-like organism, spread by insects, that infects the phloem tissue of trees of any age (Gowda and Narayana 1998). Tree death often results within 3 years of infection. Although some cultural methods of control help to limit the spread of the disease, no methods are currently available to permanently cure infected trees (Yusuf 1999).

It is estimated that as much as 80% of sandalwood from India being sold in global markets has been harvested illegally. Indian sandalwood is categorised as vulnerable according the IUCN Red List of Threatened Species (www.iucnredlist.org).

Current production in India

Illegal harvesting is still widespread in India despite official protection of the trees by the Indian Government. At the current time, it is estimated that India legally produces approximately 1,000 tonnes of wood from *S. album* per year. Illegal and unofficial harvesting may account for an additional 3,000–4,000 tonnes per year (AAG 2006).

Recent changes in regulations in parts of India may boost production levels of *S. album* in the mid to long term. However, while the production of sandalwood is a priority for India, agronomic problems and poaching are significant industry constraints (Clarke 2006). Although anecdotal reports indicate an increasing activity of sandalwood planting, the current status of sandalwood plantation development in India is unclear.

Current production in Indonesia

Indonesia has historically been a significant source of Indian sandalwood from West Timor, Sumba and Flores. The management of the resource has been poor and stocks have declined significantly (McWilliam 2001; McKinnell 2008). The natural populations of Indian sandalwood in Indonesia may be considered to be commercially spent. In the province of Nusa Tenggara, sandalwood export represented approximately 40% of total revenue between 1986 and 1991, but by 1997–98 sandalwood export represented only 16.5% of revenue (Rohadi et al. 2000), with the Provincial Forestry Service estimating a 50% reduction of wild-sourced trees from 1987 to 1997 (Rimbawanto and Haryjanto 2007). Interest in establishing commercial sandalwood plantings in Indonesia is typically low, due to the perceived long rotation (Rimbawanto and Haryjanto 2007) and the poor survival of regeneration activities carried out by the Provincial Forest Service (Rimbawanto and Masripatin 2005). Although it is possible that small stands still persist in inaccessible areas, the lack of successful plantation establishment in Indonesia

means that significant volumes of sandalwood from Indonesia may not be expected for at least 20–30 years.

Current production in Timor-Leste

Timor-Leste has native resources of Indian sandalwood that have been heavily exploited in the past (McWilliam 2001). Approximately 30 tons of sandalwood oil were exported annually from Timor during the 1960s, which declined to 7 tons in 1994 (Yusuf 1999). Only occasional parcels of logs from Timor-Leste are likely to become available in the market (McKinnell 2008). Anecdotal reports from non-government organisations operating in Timor-Leste have suggested difficulties in establishing small woodlots of *S. album*, but the reasons for these difficulties have not been clearly identified.

Future production in China

The development of *S. album* plantations in southern China is relatively recent, but significant progress has been made over the past 5–6 years (Xiaojin et al. 2011). Although the climate of southern China is subtropical, selections have been made that are adapted to these environments, and approximately 60,000 seedlings are currently being established annually (Kamwah 2010). These plantings will greatly increase the supply of Indian sandalwood; however, much of the production may be absorbed by the growing domestic demand for sandalwood products. The effect of this potential increase in supply on international prices is unclear at this stage. This development will, however, limit the potential marketing of Australian-produced Indian sandalwood into the growing Chinese domestic markets, since it would be expected that these consumers would prefer product originating in China.

Future production in Australia

Australia has seen a significant expansion in establishing *S. album* plantations in recent years, managed predominantly under large-scale managed investment schemes. The total area planted has increased significantly, from approximately 50 ha in 1999 to just under 7,000 ha in 2012 (Figure 1). The first plantation product of *S. album* is expected from 2014, and the expected yields (Figure 2) will have a major, but as yet unknown, impact on the international market. This 'new' product may create greater competitions, resulting in price decreases. It is also possible that this product will satisfy consumers of wild-sourced sandalwood products that are no longer available, as well as the expanding consumer markets in China and India.

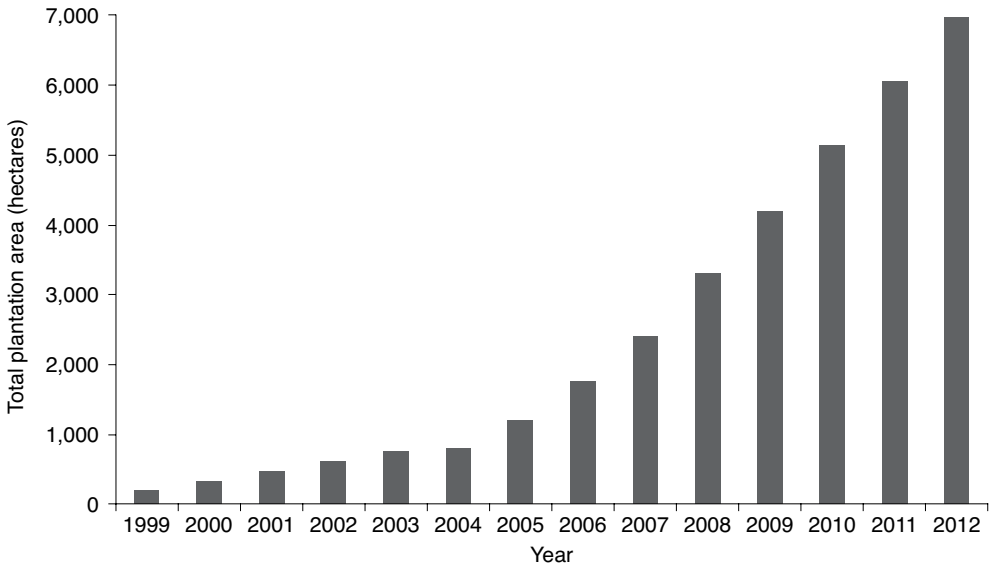

Figure 1. Total plantation area of Indian sandalwood (*S. album*) in Australia, 1999–2012 (Source: McKinnell 2008; industry estimates)

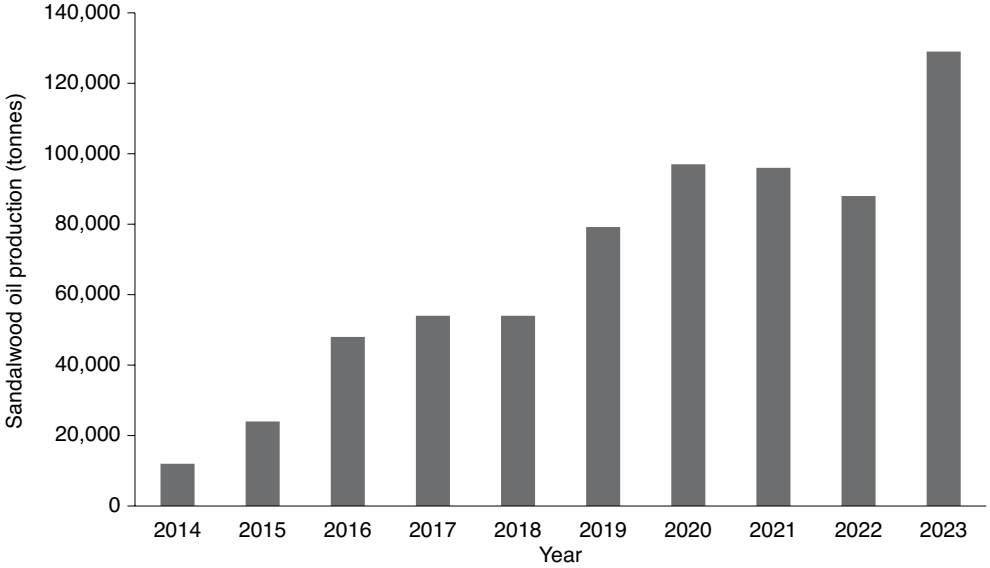

Figure 2. Anticipated yields of sandalwood oil from Indian sandalwood (*S. album*) plantations in Australia, 2014–23 (Source: Clarke 2006)

Australian sandalwood (*Santalum spicatum*)

Six species of *Santalum* grow naturally throughout Australia, but only *S. spicatum* (Australian sandalwood), which is native to Western Australia, and, to a minor degree, *S. lanceolatum* (bush plum) in Queensland are harvested for commercial use. The current estimated total area of distribution of *S. spicatum* is 161 million ha, of which 49% is protected from harvesting (AAG 2006).

Australian sandalwood accounts for the majority of the sandalwood currently harvested in Australia. The harvest of native stands is regulated by the Western Australian Government through the Western Australian Forest Products Commission, which coordinates harvesting and replanting of native sandalwood species (Adviser Edge 2008).

The agarbatti industry represents an important market for Australian sandalwood. Australian sandalwood is exported to South-East Asia for the manufacture of incense and to India for the production of oil. Taiwan and Hong Kong are the largest importers of Australian sandalwood, accounting for upwards of 60% of Australia's annual production, while China represents a significant and growing market (AAG 2006).

In addition to the natural resource, a significant planted estate of Australian sandalwood has been established over the past decade in corporate-, government- and farmer-owned plantations in Western Australia.

Current and future production in Australia

Just over 2,100 tonnes of *S. spicatum* heartwood from Crown land and approximately 200 tonnes from private landholders in Western Australia are harvested annually. Government legislation dictates that at least half this quota must be deadwood that is unsuitable for oil extraction (Clarke 2006).

With declining global supplies of sandalwood, the market outlook for Australian sandalwood is positive. To capitalise on this opportunity, the total area planted over the past 10 years has increased from approximately 650 ha in 1999 to 15,627 ha in 2012 (Figure 3). Rates of sandalwood planting in Australia, however, are likely to slow, as investor confidence has cooled since the recent insolvency of a number of managed forestry investment schemes across the country.

Although the level of santalol in *S. spicatum* is typically lower than that in *S. album*, there is still strong demand for its oil (Clarke 2006). The estimated supply of marketable oil from recently established

plantations is expected to rise substantially from 2019 when harvesting begins (Figure 4). In addition, the oil quality of heartwood derived from future plantations is likely to improve as trees with elevated levels of santalol have been identified (Hettiarachchi and Coakley 2009) and improvement programs using material derived from these trees are currently being conducted in Western Australia.

Pacific sandalwoods (*Santalum* spp.)

Pacific sandalwood species of commercial value include *S. austrocaledonicum* (Vanuatu and New Caledonia), *S. macgregorii* (listed on the IUCN Red List of Threatened Species as endangered; Papua New Guinea), *S. insulare* (French Polynesia and Cook Islands) and *S. yasi* (Fiji and Tonga) in the South Pacific; and *S. ellipticum, S. freycinetianum, S. haleakalae* and *S. paniculatum* from Hawaii in the northern Pacific. Species such as *S. yasi* and some populations of *S. austrocaledonicum* produce high-quality sandalwood products, reputedly similar in quality to *S. album* from India and Indonesia (Thomson 2008).

Many sandalwood species in the Pacific region are approaching commercial exhaustion in their native habitats. However, on a more positive note, both small and larger scale sandalwood plantations are being established in parts of the Pacific region, which will increasingly substitute the dwindling supplies from native forests (Gillieson et al. 2008; Thomson 2008). In French Polynesia, the area of sandalwood plantings established in recent years approaches several hectares (Butaud and Defranoux 2007).

African sandalwood (*Osyris lanceolata*)

Osyris lanceolata, a related species in the same family, is a multistemmed African tree that produces a heartwood oil with similar fragrant properties to *Santalum* species. African sandalwood is harvested from natural populations of *O. lanceolata* in Chad, Sudan, Ethiopia, Uganda, Kenya and Tanzania. Increased use of this species began in the early 1990s following a decline in the global sandalwood supply (Mwang'ingo et al. 2004), but the exploitative harvesting of this species in some regions resulted in a decline in the resource and disappearance of the species in some areas (Mwang'ingo et al. 2003). Much of the wood is sold on the international market and subsequently mixed with and sold as Indian sandalwood. While there is considerable variation in santalol content between populations of *O. lanceolata* (Mwang'ingo et al. 2003), the average santalol content is typically much lower than that of *S. album*. The adulteration of Indian sandalwood products with

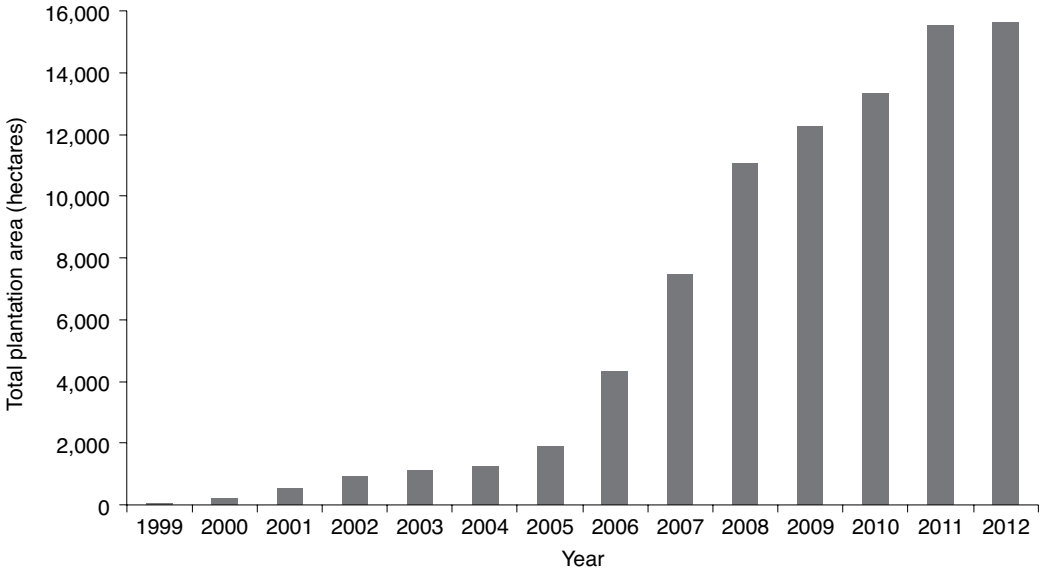

Figure 3. Total plantation area of Australian sandalwood (*S. spicatum*) in Australia, 1999–2012 (Source: industry estimates)

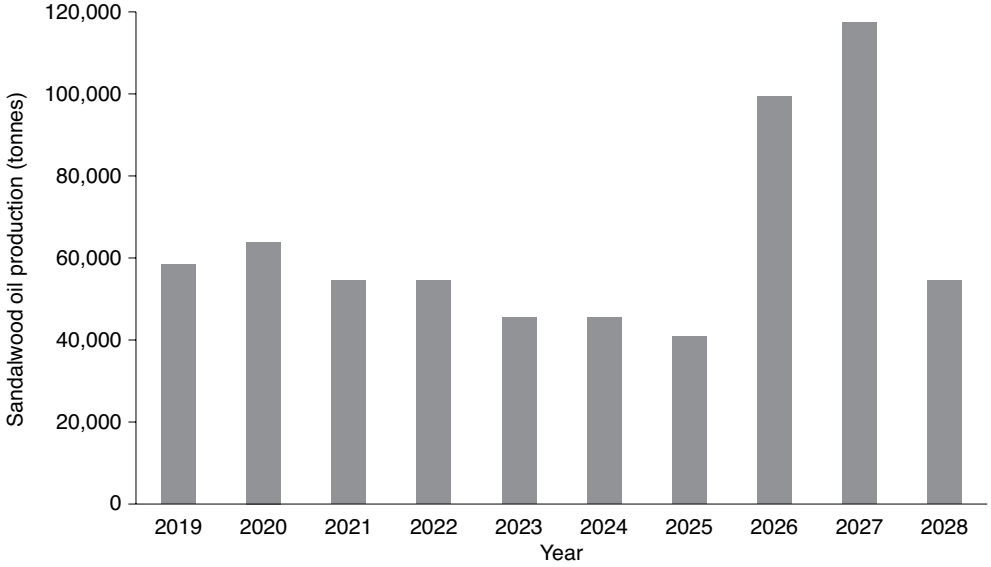

Figure 4. Anticipated yields of sandalwood oil from Australian sandalwood (*S. spicatum*) plantations in Australia, 2019–28 (Source: Clarke 2006)

imported African sandalwood has partly eroded market confidence in sandalwood products originating from India. African sandalwood is, however, expected to remain part of the global resource for the next 5–10 years (McKinnell 2008). Although there is research interest in domesticating and planting this species (Mwang'ingo et al. 2004; Teklehaimanot et al. 2004; Mwang'ingo et al. 2005; Mwang'ingo et al. 2007), it is unclear whether plantations are currently being established.

Sandalwood production in Vanuatu

The Republic of Vanuatu is an archipelago of volcanic and coralline islands in the south-western Pacific Ocean. It is located approximately 1,700 km to the east of Australia and is immediately north of New Caledonia and south of the Solomon Islands. The country spans approximately 850 km from north to south and has a land area of 12,190 square kilometres (VNSO 2007). Vanuatu has a seasonal tropical climate, with most islands experiencing wet (November–April) and dry (May–October) seasons; however, the timing and intensity of these seasons vary both within and between islands. The country experiences frequent tropical cyclones, particularly in the northern islands, which occur primarily between November and April. These intense weather events often negatively impact people's livelihoods and the economy of affected areas.

Vanuatu has a small population of approximately 243,000 people (VNSO 2009), dispersed evenly across the country but tending to areas close to the coast. Port Vila and Luganville are the main urban centres for commerce and export, but the majority (~75%) of ni-Vanuatu people live in rural areas. The population is identified primarily as Melanesian but is both culturally and linguistically diverse, with at least 80 language groups (Crowley 2000).

Vanuatu is a developing country with a small economy that, in 2008, had an estimated annual per capita gross domestic product (GDP) of US$2,388 (UNdata 2010). In 2006, agriculture employed an estimated 98% of the rural population, and produced 17% of the GDP and 73% of export earnings (VNSO 2007). Swidden agriculture is a prominent feature of the industry and contributes to the livelihoods of most of the population. Export agriculture consists of copra, coconut oil, cacao, kava, beef and timber, while smaller rural activities involve fishing and the production of coffee, vanilla and pepper (Figure 5). The reliance on so few export commodities results in highly variable export earnings between years, caused by fluctuations in global prices for these products. Vanuatu consistently runs a significant trade deficit due to the disparity in value between imports and exports, and thus requires export products of higher value with smaller price fluctuations.

Forestry sector

Approximately 75% of Vanuatu has natural vegetation, including grasslands, rainforest, dry forest and secondary growth (VNSO 2007). All islands are generally well forested and provide essential resources for the domestic economy, including materials for housing, food, fuel, medicines, rituals and trade. The export of timber contributed approximately 11% of total Vanuatu exports in 2000; however, this fell to 3% in 2007 (Figure 5). This decline in exports has been caused primarily by the decline in accessible commercial timber resources.

A significant proportion (73%) of Vanuatu's export earnings come from agriculture and its timber resources, including sandalwood. Vanuatu has a good capacity to source foreign exchange and royalties from processed timber exports and taxes (Bond 2006). However, decreasing national timber volumes in Vanuatu over the past 10 years (Figure 6) have reduced royalties available to the Vanuatu Government. This decline in timber resources has led to a substantial increase in community and private interest in producing commercially significant forestry species, primarily sandalwood and whitewood and to a lesser extent mahogany, nangai, natapoa, kauri and namamau (Figure 7).

In its National Forest Policy (1997), the Vanuatu Ministry of Agriculture, Livestock, Forestry, Fisheries and Environment set a sustainable yield for logging from native forests of 63,000 m^3. Since 1997, timber production peaked at just over 40,000 m^3 in 1999, with a more recent decline to 5,000–11,000 m^3 between 2005 and 2008 (Figure 6). This abrupt drop in production was due primarily to the departure of the largest timber exporter based in Santo. Their departure was partly due to the exhaustion of commercial timber volumes in accessible areas and the associated

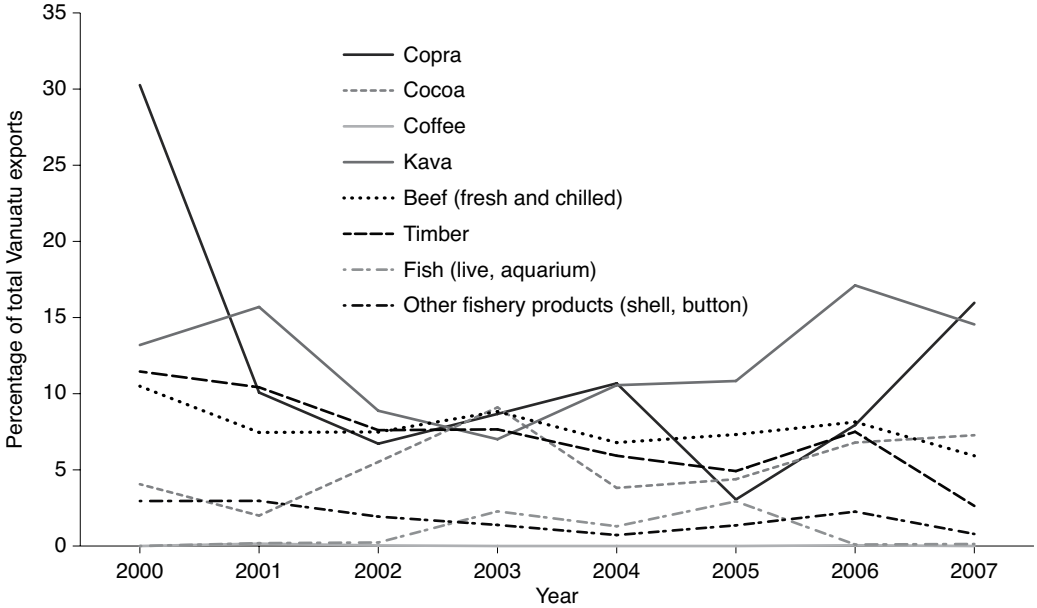

Figure 5. Relative contribution of agricultural products to Vanuatu's export earnings, 2000–07 (Source: VNSO 2007)

increasing costs of harvesting timber in isolated areas. Importantly, the Vanuatu Department of Forests (VDoF) reported that, between 1990 and 2004, white-wood comprised 60–70% of all logs harvested but, in 2008, it accounted for only 20% of the logs harvested. To sustain the current forest industry's contribution to the national economy, significant expansion of the national plantation estate will be required.

Importance of sandalwood in Vanuatu

Sandalwood has been an important part of the economy since the 1800s. The extraction and export of sandalwood in Vanuatu from the 1820s to the 1850s was the region's first international commercial industry (Shineberg 1967). Most of the sandalwood extracted during this 30-year period was traded by Australian merchants to consumers in China (Shineberg 1967). After this initial period, the industry continued intermittently as natural populations re-established to a modest commercial size (Gillieson et al. 2008). A small commercial industry has been in operation since the 1970s, and sandalwood forms the basis of a modest but important cash economy in Vanuatu, with trees grown and harvested from multiple locations.

Wild-harvested sandalwood

Traditionally, sandalwood has been harvested from wild stands by farmers/smallholders with customary rights over the land. Most smallholders harvest sandalwood for sale or to collect seedlings for planting; few use it for domestic use as firewood or for buildings/repair (VNSO 2007).

Wild-harvested sandalwood has been a valuable source of income for many Vanuatu smallholders, and 40% of respondents interviewed in our study harvested and sold sandalwood growing in the forest that they or their family owned. These smallholders came from Erromango, Tanna and Malekula, the islands that have provided significant volumes of the total annual harvest in Vanuatu (Gillieson et al. 2008).

In Vanuatu, the market for wild-harvested heartwood pays on the basis of weight. The VDoF regulates the minimum price paid per kilogram of desapped heartwood, which is reviewed annually and publicised at the beginning of the sandalwood-harvesting season.

The wood is processed in Port Vila, and various products, including sandalwood oil, heartwood, carving logs, spent charge and sapwood, are marketed.

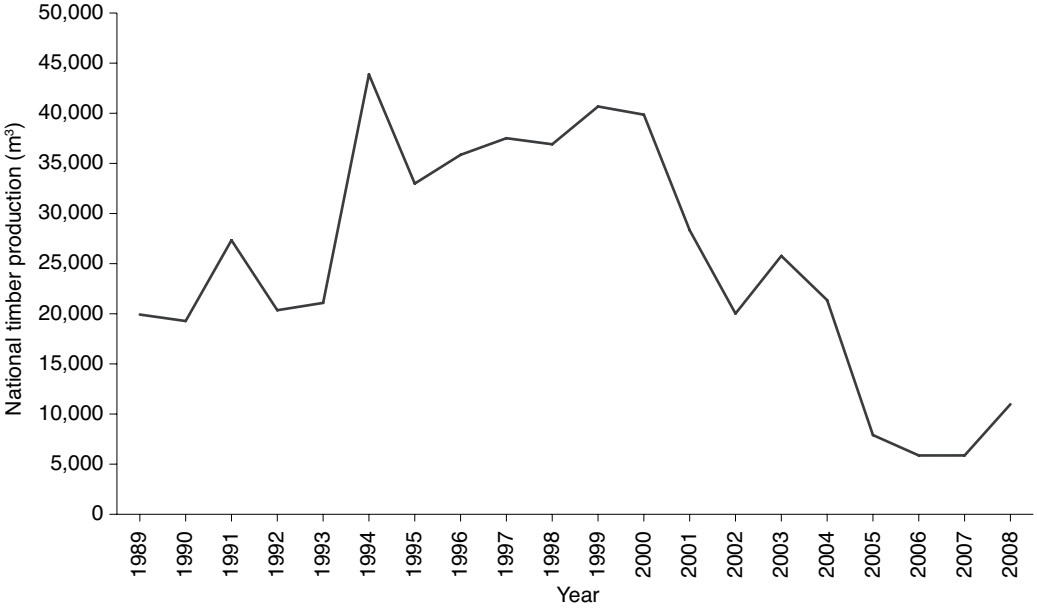

Figure 6. National timber production for Vanuatu, 1988–2008

Therefore, the industry benefits both the rural and the urban economies and provides income to the government through royalties.

Benefits to the smallholder of growing sandalwood

The heartwood and oil of sandalwood are high-value, low-volume products that can be stored without deterioration, allowing economically viable transportation from smallholder to processor and from processor to market (Bond 2006). The stable nature of the product enables commercially mature trees to be harvested at any time with minimal additional inputs. This allows smallholders to schedule harvesting when prices are higher and when they require cash.

In many areas of the sandalwood-producing islands, the trade in sandalwood constitutes a significant proportion of the annual income, where 50% of the respondents in our survey currently harvesting wild sandalwood indicated that *they were unable to earn equivalent money from other activities as they do from selling sandalwood*. Obviously, the earning power of harvesting sandalwood from natural sources would be dependent on the resource available to the landowner. In a given harvesting season, the amount of heartwood harvested varied among the respondents from 40 kg to 500 kg. The remaining respondents who harvest and sell sandalwood growing in the bush suggested that they could earn equivalent money from jobs like driving a local transport vehicle, carpentry work, providing tourist accommodation, or selling produce from a garden or cattle project.

The average harvest among the respondents was three trees, each with approximately 40 kg of heartwood. At the minimum price set by the VDoF (800 vt/kg in 2009), this equates to a seasonal earning of about 96,000 vt (~US$1,000). Smallholders used the money earned from trading wild-harvested sandalwood mainly to pay the costs of their children's school fees, which represent a significant annual expense in a family budget, and other family expenses such as food, medical bills, marriage ceremony, clothing, soap and kerosene.

Current and future production in Vanuatu

Vanuatu currently produces approximately 80 tonnes of sandalwood per year under a legislated licensing and harvesting quota. This volume equates to approximately 1–2% of world production. However, as the Vanuatu sandalwood industry is dependent on trees of wild origin, concerns over

the sustainability of wild-harvesting practices have persisted (Neil 1986; Corrigan et al. 2000; Gillieson et al. 2008), and the need for reafforestation activities to alleviate harvesting pressures on wild stands has been highlighted (Gillieson et al. 2008). Significant planting has occurred on some islands since 2000 (Thomson 2006), and interest in planting sandalwood now crosses many socioeconomic classes and includes smallholder farmers, village chiefs and leaders, wage earners, professional workers, expatriate residents and foreign investors.

Sandalwood plantation sector in Vanuatu

Throughout history, the Vanuatu sandalwood industry has been based solely on trees harvested from wild stands. The most effective way to ensure that the industry remains sustainable and commercially viable over the long term is to establish a planted resource. Recognising this, the Vanuatu Department of Forests (VDoF) began actively promoting sandalwood planting during the 1990s. In 2002, this initiative was formalised in the first objective of the department's Sandalwood Policy: to 'increase sandalwood stock through replanting' (VDoF 2002). This policy also outlined that future sandalwood purchasing licences would only be issued to 'applicants who have … actively participated in sandalwood reforestation'. Several anecdotal reports have indicated that smallholder sandalwood planting is increasing (Sam and Thomson 1999; Robson 2004; Tate et al. 2006; Thomson 2006; Lini 2007), but it is important to systematically evaluate the level of planting across Vanuatu and thus the effectiveness of government promotion of this activity. In recent years, an agricultural census, a woodlot survey and our work (interviews and surveys in 2008) have attempted to assess the level of planting by smallholders of sandalwood and other tree species across the country.

Woodlot survey

To assist smallholder tree planting, the Vanuatu Chamber of Commerce distributed more than 1.9 million nursery poly bags between 2003 and 2007. To determine the impact of this initiative, in 2007 the chamber surveyed 1,018 smallholders across 17 islands of Vanuatu about the species they planted, the date and number of trees they planted, and the density of their plantings.

The survey revealed that both sandalwood and whitewood featured prominently in the numbers of trees planted (Figure 7). In both cases, the international demand for these products is strong, and local processing and export creates a demand for smallholder-produced trees. Whitewood produces a low-density timber used primarily for framing and furniture making, and, in contrast with sandalwood, is well adapted to the wetter areas of Vanuatu. These two commercial species therefore offer smallholders the opportunity to select the one most suited to their local climate.

Other trees planted include mahogany, natapoa and kauri, which are typically sold for timber to local sawmillers for local use and regional export; nangai, which is also a good timber species, and produces nuts for household consumption and sale to local processors; and namamau, from which the logs are used as poles primarily for local construction and fences.

Domestic use of sandalwood

In the 2007 Vanuatu Agricultural Census, 8.75% (2,813) of the 32,096 households surveyed indicated that they gathered naturally occurring sandalwood for firewood, building/repair, sale, sawmilling and seedlings for planting. This census allowed each family to report more than one use (VNSO 2007).

Approximately 1.6% of these households indicated that they gathered sandalwood for firewood (possibly agarbatti; 33 households) and building/repair (possibly carving; 12 households). It is unclear whether households collected sandalwood for the sole purpose of firewood. It seems likely that the waste sapwood was burned following its removal from the marketable heartwood, or alternatively it may have been used as incense. During our interviews and discussions with sandalwood harvesters between 2004 and 2008 (independent of the national agriculture census), the only use for harvested sandalwood was for sale to local exporters, so the true extent of use for buildings/repair, although unclear, is probably minimal. Despite this lack of clarity, the results are nested within the harvesting for sale and for planting, and therefore these two categories account for all respondents. The total of these categories is 156 households greater than the total number gathering sandalwood (2,813), which represents the number of households that gather sandalwood for both sale and planting (Table 1).

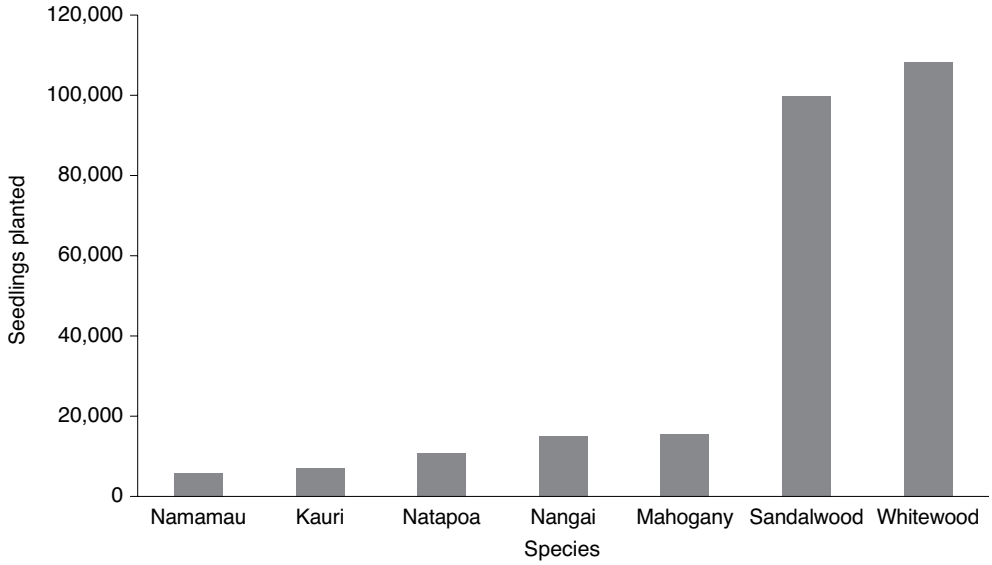

Figure 7. Seedlings planted across 15 islands in Vanuatu between 2000 and 2006 for six indigenous (kauri—*Agathis macrophyla*, namamau—*Flueggea flexuosa*, nangai—*Canarium indicum*, natapoa—*Terminalia catappa*, sandalwood—*Santalum*, whitewood—*Endospermum medullosum*) and one exotic (mahogany—*Swietenia mahogany*) tree species

All sandalwood gatherers were involved in the trade and/or planting of sandalwood. It is conspicuous that 60% of the households 'gathering sandalwood' were involved exclusively with its planting. These households may have fully exploited their wild custodial resources and are now in the process of replanting, or may be households without any historical ownership of wild sources of sandalwood. While it is not possible to determine the proportion of these two categories, it is likely that part of the 60% represents a completely new source of sandalwood, which will help in distributing the economic benefits of the species more equitably. Regardless of the demographic makeup of this category, it is encouraging that households planting sandalwood represent a much greater proportion than those harvesting for sale (Table 1).

Planting sandalwood in Vanuatu

Sandalwood occurs naturally on eight main islands of Vanuatu (Santo, Malekula, Efate, Erromango, Aniwa, Tanna, Futuna and Aneityum), but another eight islands have areas with climatic and edaphic conditions suitable for its production (Malo, Aore, Ambae, Pentecost, Ambrym, Epi, Paama and Shepherd) (Gillieson et al. 2008). The latter eight islands, all north of the central island of Efate, have little to no planted sandalwood established in smallholdings. Establishing sandalwood production over a wide geographical area will enable the Vanuatu industry to increase overall volumes.

In recent years, smallholders have begun to plant sandalwood seedlings in garden areas within the swidden agricultural system; these trees persist in the regenerated forest after the garden is abandoned. Early growth of sandalwood trees in such systems is greater in newly established than in older (3–4-year-old) gardens. Sandalwood seedlings are also being established in native forests as enrichment plantings and within the village as 'specimen' plantings.

Between 2000 and 2006, the annual planting rate was 14,270 sandalwood trees (99,890 trees in total), which was significantly ($P < 0.05$) greater than for the previous 7 years (1993–99) when the annual planting rate was 478 trees (3,346 trees in total) (Figure 8). Therefore, 96% of the sandalwood plantings recorded in the 2006 survey occurred between 2000 and 2006 (Figure 9). These were established by 305 smallholders, with an average of 327 trees per smallholder (Table 2). Approximately 86% of the

Table 1. Number of households that gather sandalwood for sale and planting

Purpose for gathering sandalwood	No. households	% households
Sale only	959	34
Sale and planting	156	6
Planting only	1,698	60
Total	**2,813**	**100**

Source: VNSO (2007)

smallholder plantings were in the south of Vanuatu (Tafea province) where natural sandalwood stands remain. Sandalwood plantings in Vanuatu are generally established using seedlings raised in village nurseries. Interviews with leading sandalwood smallholders in Vanuatu found that the average number of trees planted by them was 886. The two licensed sandalwood merchants in Vanuatu combined have planted approximately 150 ha in Efate. Furthermore, recent foreign investment in smallholder sandalwood has resulted in the establishment of 16 joint-venture plantings in Erromango and Tanna. The mean number of trees planted (4,000) under these arrangements is 12.5 and 4.5 times the number measured in the 2007 survey and 2008 interviews, respectively.

The 2007 Vanuatu Agricultural Census recorded 1,854 people who were planting sandalwood. While the 2007 woodlot survey found that the mean planting rate per smallholder was 327 (Table 2), we propose that this may overestimate the level of planting across all smallholders since those participating in the woodlot survey were those who received free planter bags. We arbitrarily determined that the mean level of planting among those responding to the agricultural census may be approximately 110 trees each. Taking planting rates of the woodlot survey as the maximum and the subjectively adjusted figures as the minimum, we estimate the establishment of between 303,000 and 607,000 sandalwood trees by smallholders in Vanuatu. As the majority (66%) of smallholders in the woodlot survey planted at a density of 3 m × 3 m, this represents between approximately 270 and 550 hectares of smallholder sandalwood plantings. Adding the 150 ha of larger plantings established by the two sandalwood buyers, this represents a total national planted resource of 420–700 ha.

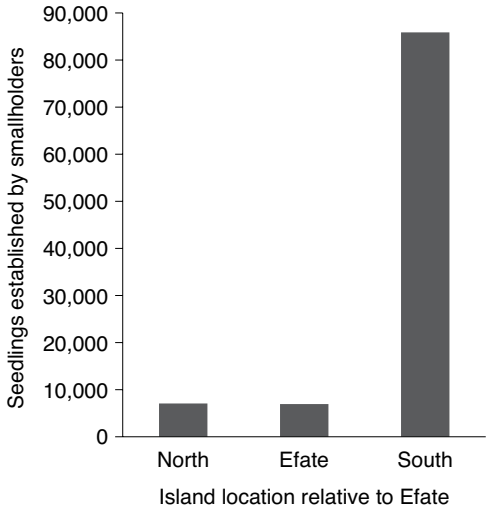

Figure 8. Number of sandalwood seedlings established by smallholders between 2000 and 2006, as measured in the 2007 woodlot survey and stratified by the island location relative to Efate

The marked increase in sandalwood planting rates since 1999 may have been influenced by the combined effects of:

- the active promotion of tree planting in general, and sandalwood planting in particular (VDoF 2002), helped by research and extension activities of Australian Centre for International Agricultural Research-funded sandalwood projects (Gillieson et al. 2008; Page et al. 2008)
- the distribution of planter bags free of charge through the Vanuatu Chamber of Commerce
- a decreasing wild resource (Gillieson et al. 2008)
- increasing prices paid to landowners for sandalwood at an annual rate above that of the Vanuatu consumer price index (Figure 20).

Improved sandalwood stock

Through the systematic evaluation of the wild populations of sandalwood across Vanuatu, a number of trees producing high-quality heartwood oils (i.e. high levels of α-santalol) were identified (Page et al. 2010). Assuming that oil quality has a moderate to high

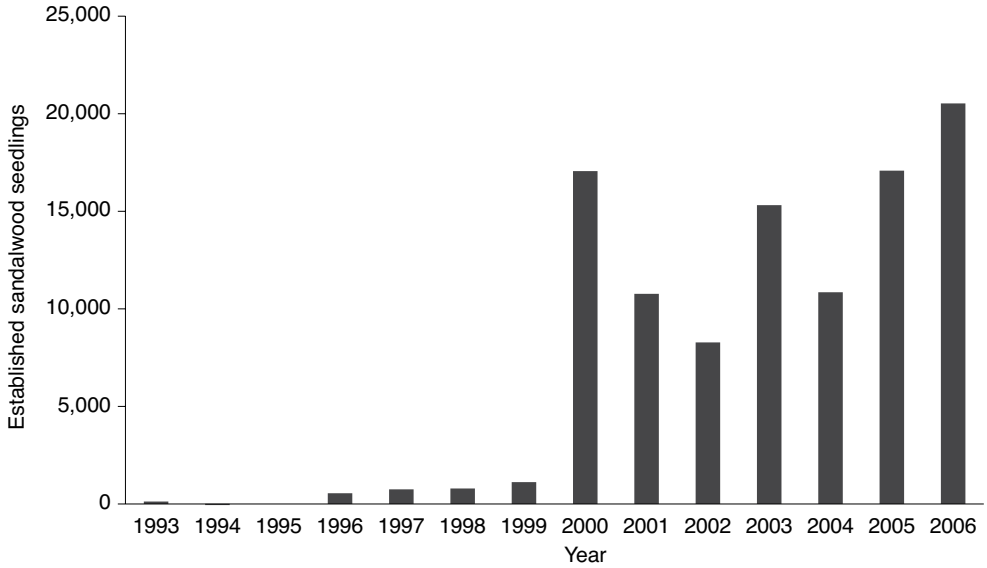

Figure 9. Numbers of sandalwood seedlings established in smallholder plantings in Vanuatu, 1993–2006

Table 2. Planting of sandalwood by smallholders across nine islands in Vanuatu between 2000 and 2006 as measured during a woodlot survey in 2007

Island	Smallholders	Mean seedlings	Total seedlings
Santo	5	372.0	1,860
Ambae	21	100.5	2,110
Malekula	13	238.5	3,100
Nguna	1	222.0	222
Efate	4	1,680.5	6,722
Erromango	76	478.2	36,340
Aniwa	92	238.5	21,939
Tanna	39	288.7	11,260
Aneityum	54	302.5	16,335
Total/mean	**305**	**327.5**	**99,888**

narrow-sense heritability, use of germplasm derived from these trees could improve the niche market opportunities for this product. Subsequently, the selected resource has been secured as a grafted seed orchard in the Vanuatu Department of Forests nursery on the island of Efate. To ensure the participation of all relevant smallholders in the Vanuatu sandalwood industry, this improved material needs to be available to smallholders on all islands with a climate and soil suitable for the production of sandalwood. This will facilitate wider adoption of sandalwood agroforestry and build a more substantial and high-quality resource that will benefit the marketing of Vanuatu sandalwood. These developments can result in improved smallholder and national income, and ultimately improve livelihoods.

Planted sandalwood species

The sandalwood industry in Vanuatu is currently based on *S. austrocaledonicum*; however, growing other species of sandalwood has been considered. Since 2008, a small number of *S. album* trees have been planted on Efate, with some industry leaders actively promoting its planting throughout Vanuatu.

Proponents of further expansion of *S. album* plantings suggest that, as it produces heartwood with a higher santalol content, this will enable Vanuatu to compete successfully in the international marketplace. Conversely, there is a high likelihood of other species hybridising with *S. austrocaledonicum*, and it has been suggested that dilution of *S. austrocaledonicum* genetic resources through hybridisation with *S. album* can reduce species diversity, which is important for conservation and efforts for future improvement.

With the high growth rates of the *S. yasi* × *S. album* hybrids in Fiji, it has been proposed that an increase in tree vigour may also be achieved with *S. austrocaledonicum* × *S. album* hybrids in Vanuatu, although it is not known what effect this may have on the length of rotation, as *S. album* has a longer rotation than *S. austrocaledonicum*.

Opponents to the further introduction of *S. album* cite market advantages for producing 'pure' *S. austrocaledonicum* heartwood products, because differentiation from Indian, Fijian and Australian product can be an advantage in the marketplace by increasing the opportunity for niche marketing.

Economic advantages from planted sandalwood

The medium- to long-term prospects for the industry are optimistic due to the projected high value of sandalwood in world markets, the level of sandalwood planting currently being undertaken and the resulting increase in the size of the Vanuatu resource from 2020, as planted stocks begin to mature. The projected increase in sandalwood supply in Vanuatu will begin in 2015, associated with the harvesting of planted resources established around 2000 (Figure 9). This assumes that half the trees are harvested after 15 years and the other half at 20 years. As many trees were established when information on site selection and management was limited, more conservative heartwood estimates (18 kg at both 15 and 20 years) are used in this projection than are measured in this report (Figures 12 and 13). We also assume that the wild resources will decline to approximately 30 tonnes by 2015 given the low total volume (209 tonnes) of the resource estimated in 2008 (Gillieson et al. 2008). The planted resource will begin to come 'on line' in 2014 and possibly bring production back up to approximately 80 tonnes in 2015. This additional planted resource will gradually build over the next decade, and the industry may be able to sustain annual production at around 120–150 tonnes between 2020 and 2025 and possibly over 300 tonnes by 2029–30 (Figure 10). By this time, the planted resource would therefore represent about a fourfold increase in annual harvesting rates and subsequent value of the industry, when compared with the current 80 tonne annual quota. With a continuation of the current planting activity, the Vanuatu industry can consolidate and improve its position as a small, niche producer within the international marketplace.

The agroforestry approach for securing future sandalwood supplies with genetically diverse and improved planting stock can potentially increase the total value of the industry since it has a number of advantages over the current wild-harvest industry:

- The planting of trees across a wider geographical area than the natural stands will facilitate improved distribution of economic impacts for smallholders across the country and reduce the risk associated with natural disasters.
- The integration of tree production within existing swidden agricultural systems can be undertaken with only minimal additional costs.
- Production within existing agricultural systems can reduce the incidence of resource disputes, since ownership of planted trees is less likely to be challenged than ownership of wild trees.
- Integrated sandalwood agroforests can also help to reduce the dependence on, and subsequent over-exploitation of, natural sandalwood populations.

In addition, further expansion of sandalwood planting across Vanuatu could multiply current export earnings by many times and help satisfy an increasing international demand.

Impediments to the expansion of a planted sandalwood resource

A major impediment to developing a genuine agroforestry-based sandalwood industry in Vanuatu is the scarcity of seed supplies, largely resulting from an unreliable supply from natural sources (Lui and Smith 2007). The limited local supply of sandalwood seeds has resulted in a 2.5–20-fold increase in the unit cost of seed between 2005 and 2008 (Table 3). A similar rise in the price of sandalwood seedlings has stimulated the establishment of a lucrative nursery trade in urban areas, but has put the goal of establishing sandalwood smallholdings beyond the reach of many subsistence farmers. Sandalwood seed supply in Vanuatu comes primarily from the southern islands

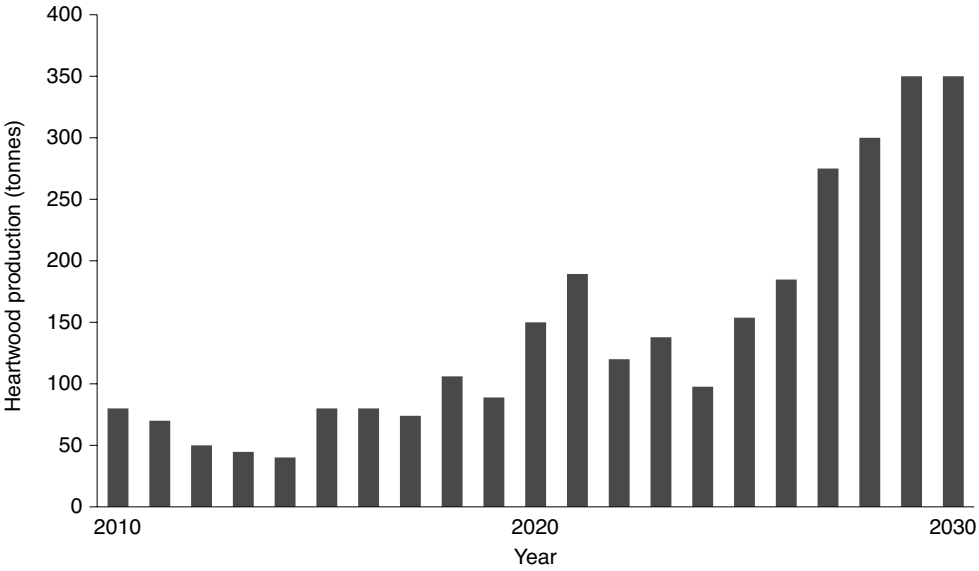

Figure 10. Broad estimates of heartwood production in Vanuatu, 2010–30 (Source: Averages of informal industry estimates and data on level of sandalwood planting—see Figure 9)

province of Tafea (Tanna, Aniwa, Futuna, Erromango and Aneityum). Although 81% of the smallholders interviewed in this study indicated that they had sufficient seeds for their sandalwood planting goals, seed availability in the northern islands is highly restricted: all smallholders interviewed from the three northern islands (Santo, Pentecost and Malekula) indicated that they had insufficient sandalwood seed for their planting goals. The higher price for sandalwood seed originating in the northern compared with the southern islands (Table 3) reflects the higher quality heartwood oils and the more pronounced shortage of seeds from trees of the northern islands.

Although the volumes of sandalwood seed in the Vanuatu marketplace have not been quantified, it is estimated that seed available in the open marketplace from wild stands may reach approximately 125,000 (~35 kg) per year. With approximately 100,000 plants established in smallholdings between 2000 and 2006, this number may be sufficient to meet current planting rates. It appears, however, that the seed collection and distribution networks may not be sufficient to ensure that all existing local seed demands are met. The bulk of the seed originating in the south does not appear to be traded widely, since a substantially lower number of seedlings was planted in Efate or the northern islands than in the southern islands (Figure 8).

There is a need to develop seed orchards and exploit the improved grafted clones selected largely on elevated levels of α- and β-santalol (Page et al. 2008). Establishing clonal seed orchards based on improved selections has the capacity to rapidly increase the available seed to meet existing high demand. The grafted seed orchards established by the end of 2013 have the capacity to attain peak seed production of 1,000 seeds per tree within 3 years. It is expected that the trees established with seed from the grafted seed orchard will attract a 50% premium value for their quality, based on existing price differences between *S. austrocaledonicum* and *S. album*. This price premium will provide additional value to these plantings and result in higher smallholder incomes than using wild-sourced seedlings alone. With new smallholder plantings providing an additional source of seed within 3–4 years of establishment, the annual sandalwood seed supplies may be estimated to be 3.5 and 11.6 million seeds by 2020 and 2025, respectively.

The limited availability of planter bags, particularly for smallholders, is also an important constraint to industry development. Boxes of planter bags (~6,000 units) are often not available in the major centres of Luganville and Port Vila, since they are often pre-sold before importation to relatively wealthy urban wage earners, who have planting

Table 3. Mean seed germination percentage and price for commercially supplied sandalwood seeds for eight islands in Vanuatu

Region	Island	Mean seed germination (%)	2005 price (US$/kg)	2008 price (US$/kg)
South	Tanna	80+	2.50–12.50	6.25–37.50
South	Erromango	70–80	6.25–12.50	12.50–37.50
North	Santo	70–80	6.25–12.50	87.5–250
North	Malekula	60–70	na	62.50–187.50
South	Aneityum	40–50	na	na
South	Aniwa	50	2.50–6.25	12.50–37.50
South	Futuna	20–30	na	na
Central	Efate[a]	–	6.25–12.50	62.50

– = not applicable; na = not available

[a] The commercial seed in Efate is sourced primarily from the islands of the southern Tafea province (Tanna, Aniwa, Futuna, Erromango and Aneityum).

Note: The number of seeds per kilogram ranges from 3,300 to 4,500 depending on seed size.

interests in their home village. Although this interest is encouraging, further competition in the planter bag market is required to ensure that people of all demographics have the opportunity to participate in this potentially lucrative agroforestry industry. Opportunity exists for greater competition to meet the high demand for planter bags.

Risks to successful sandalwood cultivation

The greatest perceived threat to sandalwood plantings attaining a full rotation was that of regular cyclones in Vanuatu. The impact of lower category cyclones can be limited by including windbreaks and planting among existing vegetation. In such protected situations, cyclones may damage the trees without a complete loss. Apart from siting a sandalwood plantation in more sheltered areas, and establishing effective vegetative windbreaks, there is limited capacity for mitigating the effects of high-intensity cyclones and therefore this may represent the greatest natural risk to achieving a full rotation.

The fungal disease *Phellinus noxious* (navwun) is possibly one of the greatest biological threats to sandalwood trees. It can kill trees of all ages, and if left unchecked in a planting can kill a large number of sandalwood trees. No chemical control agents have been registered for use against this disease, but a number of traditional methods of control (see Page et al. in press) are effective in limiting the spread of the disease within a planting.

Sandalwood in Vanuatu is not tolerant of fire, and this represents a risk in areas where wildfire is an issue, such as dry areas with bamboo (*Bambusa* sp.) or cassis (*Leucaena leucocephala*). Although such fire-prone areas are not widespread in Vanuatu, planting in these areas is not recommended. The planting of fire-resistant trees such as mango may serve as an effective firebreak to protect plantings.

The possibility of sandalwood tree theft is quite real in Vanuatu, particularly for larger plantings and those established in isolated areas. Establishing plantings in areas that are regularly visited and also fencing them will help to reduce the incidence of theft. Some respondents cited that jealousy and subsequent vandalism may be an issue; however, as more people establish small woodlots, these issues are likely to be isolated.

Investment opportunities in sandalwood plantings in Vanuatu

Individual investors, both domestically and internationally, have the opportunity to invest in a managed sandalwood project through Summit Estate. Its prospectus offers individuals small areas of planted sandalwood called ‘miniplantations’, each of which is approximately 1,032 m^2 with 140 *S. austrocaledonicum* trees. A miniplantation can be purchased for A$25,000 and is managed by Summit Estate for the entire rotation (15 years). Summit Estate estimates that at harvest each tree will have 12 kg of carving log–quality heartwood, 12 kg of incense-quality heartwood and 24 kg of sapwood. Summit Estate will process and market the final sandalwood products through its sandalwood buyers licence for a fee of 20% of the farm-gate price. Based on its pricing of

each of the three products, Summit Estate estimates that the miniplantation will be worth A$251,328, of which 80% (A$201,062) will be returned to the investor, resulting in an internal rate of return of 15%.

Joint-ventures between international investors and local planters have been in operation for a number of years. The contracts are structured so that the investor provides capital such as seedlings, chainsaws, fencing, tools and labour, while the landowner provides the land and management. The sandalwood trees are jointly owned until harvest, when the trees are divided equally among the partners. Under these agreements, each partner has the right to individually market their own sandalwood. These joint-ventures are highly dependent on trust and regular communication. In the past, regular communication between partners has been problematic, and issues in the field could not be easily reported to the investor. In some cases, the joint-venture model has worked very well, but in others many trees were not successfully established in the field. With the liberalisation of the telecommunication industry in early 2008, mobile phone coverage has increased from 20% of the population in 2007 to 75% in 2008 (AusAID 2009). The costs of handsets, SIM cards and calls are also now affordable for most of the population. This means that communication between investor and smallholder is becoming less of an issue, but the mixed success of joint-ventures in the recent past means that investors are not currently seeking these partnerships.

While most smallholder sandalwood planters intend to maintain the planting for sale at maturity, some seek to use their immature plantings as a source of income. Some smallholders have expressed an interest in selling a proportion of their trees at current standing value and then being contracted by the buyer to maintain them until maturity, when the buyer sells the trees and retains all the proceeds of that sale. Such agreements would give these smallholders a modest sum of money on sale, as well as a small annuity for maintaining those trees. Investors seeking to secure such plantings would need to develop strong relationships with these smallholders, given that the success of these investments is heavily dependent on trust.

Sandalwood plantings for use as collateral

With a rotation of at least 15 years before making any return, the economic benefits of plantation sandalwood may only be realised well into the future. Many smallholders have expressed interest in using their immature sandalwood plantings as collateral for securing a personal loan. The use of sandalwood in this way can help to bring forward the benefits of planted sandalwood to support business opportunities and stimulate local economic activity. The Personal Property Securities Act (No. 17 of 2008) allows crop assets to be used as security for loans, and the National Bank of Vanuatu can use an immature sandalwood planting as security for microfinance. The likelihood of a smallholder farmer securing such a loan is limited, since the bank considers them as unemployed with little capacity to service the loan. Wage earners with interests in sandalwood planting are more likely to be successful in meeting the requirements of the bank for these loans. Other financial institutions currently will not consider sandalwood, at any stage of maturity, as security for loans. These institutions often cited the high vulnerability of these assets to natural disaster, the logistical constraints of liquidating these assets on default, and that many smallholder farmers have no reliable source of income to repay these loans.

While there are limited avenues for a smallholder to draw on their sandalwood planting before it is mature, there are some ways to assist with the costs of establishing a sandalwood planting. One of the currently licensed sandalwood buyers offers grower agreements whereby they provide support in the form of planter bags (which can be difficult to source), and 5 years after planting an inventory is carried out and a small annuity paid for standing trees. In return for this support, the grower agrees to sell their sandalwood exclusively through this licensed buyer. The licence holder benefits from the assurance of a more reliable supply, which can assist in securing and holding export markets, and the smallholder benefits from the modest but regular income during the maturation of their sandalwood planting.

Vanwods is a microfinance institution based in Vanuatu with a focus on providing financial and business development services for women in Vanuatu. Vanwods has approximately 5,000 members in the islands of Santo, Malekula and Efate, with an additional 2,000 members from Tanna expected by the end of 2010. The members are structured in centres and groups, where each centre is made up of 35 women consisting of seven groups of five women each. Each group is typically comprised of close friends and family members. Each member is initially issued with a savings account, and the five women

support and encourage financial discipline within the group. The performance of these groups in savings is used to determine their eligibility to service a loan. Loans are issued to groups and divided among the five members. If one member defaults on her loan payments, the other group members are obliged to meet the shortfall to ensure the loan is serviced. This loan system is based on trust, and generally groups will only form if there is trust among all members.

Within this microfinance structure, Vanwods is aiming to distribute 100 seedlings to each member, who will plant and maintain the trees. After 5 years, each centre will do an inventory. Standing sandalwood aged 5 years will then be used as security for members seeking to secure modest loans in the future. While tree losses during establishment are likely, even if only a modest 50% survival is achieved, this will equate to approximately 250,000 sandalwood stems (approximately 230 ha at 3 m × 3 m spacing) established within the next 12 months. This level of planting is more than twice the number of trees established by smallholder farmers as measured within this study (Table 2). The Vanwods sandalwood program is currently using this project's developed extension materials to build the capacity of its members to successfully establish sandalwood plantings and limit the potential losses.

Productivity of planted sandalwood

The value of a sandalwood tree is largely determined by the weight of its heartwood and the concentration and composition of the oil contained within it (Doran et al. 2005). Determining the rate of heartwood development in a sandalwood tree is important, since it will largely determine the length of its commercial rotation. The weight of the heartwood is invariably limited by, or dependent on, the size of the tree. Very little information has been published regarding the rate of growth in *S. austrocaledonicum*.

Growth rates

Growth rates were measured in 1,685 sandalwood trees planted across five islands of Vanuatu (Santo, Malekula, Efate, Erromango and Tanna). Four broad management regimes were identified:

- commercial—intensively managed with fertiliser added
- enrichment—planted within an existing natural namariu (*Acacia spirorbis*) forest
- new garden—planted in a newly cleared garden at the same time as all other crops
- old garden—growing in a garden area no longer used as such.

Given the prevalence of both enrichment and new garden plantings, the number of trees measured in these two categories constituted 84% of the trees sampled (Figure 11). No statistical differences in the mean annual basal increment were found between these two planting types, with a basal diameter growth rate of 1.08 cm per year. Sandalwood grown under commercial conditions was found to have significantly greater growth rates than all other management regimes, largely due to the attention to host-tree planting and fertiliser additions. Trees planted in old garden areas were found to have significantly slower growth rates than all other management regimes.

Although 93% of the data were collected from trees aged 10 years and under, these differences in early growth rates are likely to persist in later years. In the commercial category, only two growers were sampled, one in each of Efate and Santo. The maximum age of these trees was 3 years (as these were the only ones available) and, given the higher relative growth rates of *S. austrocaledonicum* in its earlier years (Thomson 2006), this sampling regime is likely to elevate the growth rate estimates of the commercial plantings relative to the enrichment and new garden plantings. Although the sample size of the old garden category was also small, the age classes represented ranged from 3 to 13 years, and the data collected for this category are likely to reflect the growth rates relative to the enrichment and new garden plantings.

Heartwood development

As for growth rates, there have been few studies on the rate of heartwood development of *S. austrocaledonicum*, and estimates based on *S. album* (Rai 1990; Haffner 1993; Radomiljac et al. 1998) may not be applicable to sandalwood in Vanuatu. Many sandalwood resource owners, and more particularly agents and buyers in Vanuatu, have experience in determining the approximate weight of heartwood in a standing tree of a known age. This study drew on this experience and used an agent of one of the existing sandalwood licence holders with more than 10 years experience to determine the weight of heartwood across 109 trees of a known age growing on the main production islands of Tanna and Erromango. Although the heartwood weights are based on estimates, every effort was taken to verify the figures with experienced industry participants. Therefore, we are confident that these data provide a reasonable reflection of heartwood development in *S. austrocaledonicum* growing under appropriate conditions in Vanuatu. Further research would improve the accuracy of these data.

The regression between tree age and heartwood weight indicates that heartwood development may begin at 7.5 years, and increase at a rate of approximately 2.5 kg per year thereafter (Figure 12). While the R^2 value of 0.71 indicates that age explains much

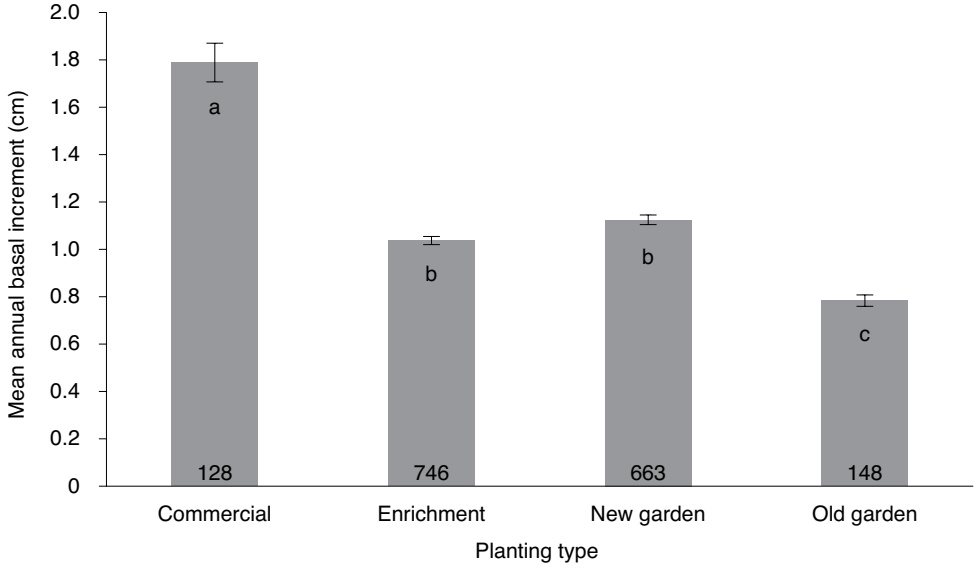

Figure 11. Mean annual basal increments of *S. austrocaledonicum* grown in Vanuatu under four different management regimes. Vertical bars denote standard errors, and regimes sharing a lower case letter are not significantly different. Numbers at the base of each category represent the number of trees sampled.

of the variation in heartwood weight, there is still substantial variation between trees of similar age. This variation may be due to differences in genotype and local edaphic and/or climatic conditions. Hook (1997) made preliminary estimates of heartwood development in *S. austrocaledonicum* growing in Vanuatu by measuring diameter at breast height (DBH) and heartwood yield for trees growing in Aniwa and Tanna. If we apply the taper proportions measured in our study, where the DBH was 76.4% of the basal diameter, and apply the generalised 1 cm annual basal diameter increment, a tree of 11.5 cm DBH in Hook's study would have a basal diameter of 15 cm. According to Hook's regression, a sandalwood tree of this size should have approximately 22 kg of heartwood. This level of heartwood development is similar to the 18 kg as estimated by our linear regression (Figure 13). Furthermore, the heartwood yield estimate for a 30-year-old tree based on our regression (59 kg) (Figure 12) also fits within the broad estimates of Thomson (2006) for a tree of this age (50–100 kg). These estimates are, however, much lower than those found for similar-sized *S. austrocaledonicum* trees on the Vanuatu island of Erromango (~60 kg) (Tacconi 1994) and in New Caledonia (~123–136 kg) (Cherrier 1991; Nasi 1994). The exact basis for these differences in heartwood weight between studies is unclear. All these studies, however, found marked variation in the weight of heartwood between similar-sized trees. It is possible that differences in heartwood weight may be due to differences in tree age rather than size, since growth rates may vary between trees and sites sampled.

Using the more conservative estimates in this and other publications (Hook 1997; Thomson 2006), the development of heartwood in *S. austrocaledonicum* appears to occur earlier (more precocious) and with greater volumes than in *S. album*. Using the regression of heartwood weight and tree diameter (DBH) for *S. album* in Timor developed by Fox and Millar (2001), it may be estimated (using the tree taper calculations of this study) that heartwood development begins in an *S. album* tree with a basal diameter of 20 cm. Under appropriate growing conditions, an *S. austrocaledonicum* tree with a basal diameter of 20 cm was conservatively estimated to be between 36 kg (this study) and 47 kg (Hook 1997).

Growing conditions

Importantly, all people interviewed during this study expressed that there was a strong association between the rate of heartwood development and

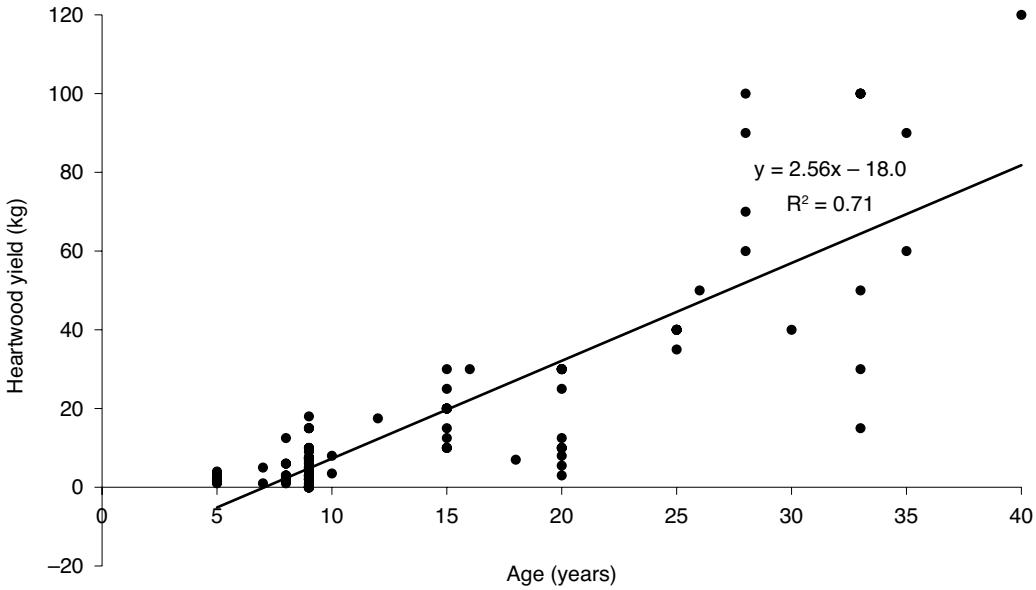

Figure 12. Relative weight of heartwood among sandalwood of different ages, sampled in Tanna and Erromango

each of soil type, rainfall and the level of sun exposure on the canopy of the sandalwood. Among the experienced respondents, there was consensus that sandalwood growing in a shallow soil or one with a high level of stone inclusions, together with a distinct annual dry period, and exposure to full sun developed heartwood rapidly. The expected period for harvest under these conditions was 15–20 years, but may be as much as 30–40 years for trees growing in contrasting areas of deep, fertile soil, high and evenly distributed rainfall throughout the year, and a shaded canopy. Rai (1990) proposed that environmental factors imparting stress on a sandalwood tree were important in the promotion of heartwood development in *S. album*. It is possible that the differences in heartwood development between different environments may account for the discrepancies in the estimated rotations for many sandalwood species (Doran et al. 2005).

The development of heartwood is most pronounced in the roots and base of the tree, and gradually reduces towards the trunk and branches. Low branching limits the development of the heartwood into the canopy of the tree and therefore reduces the potential value of the tree at harvest. However, pruning at an early age (years 1–3) can substantially reduce the incidence of low branching and promote the development of a single bole. This improvement of tree form can potentially increase the individual tree value and thus the profitability of planted sandalwood. A tree with a single bole and clear grain heartwood also has the potential to produce high-value carving logs. Therefore, the widespread use of pruning to bring about such a commercial form can potentially increase the overall value of the planted industry in Vanuatu with minimal investment in the form of labour.

Planting spacing and host plants

All species of *Santalum* are hemiparasites, forming haustorial root connections with the roots of a wide range of species, including annual and perennial crops (Tennakoon et al. 1997; Tennakoon and Cameron 2006). While much has been written about the benefits of hosts (Tennakoon et al. 1997; Radomiljac and McComb 1998; Loveys et al. 2002; Barbour 2008), good productivity of *S. austrocaledonicum* over many years occurs in plantings with few large woody hosts, provided that sandalwood spacing is not lower than 3 m × 3 m. It is likely that sandalwood gains much benefit from forming associations with many herbaceous crops and weeds, particularly the prevalent leguminous

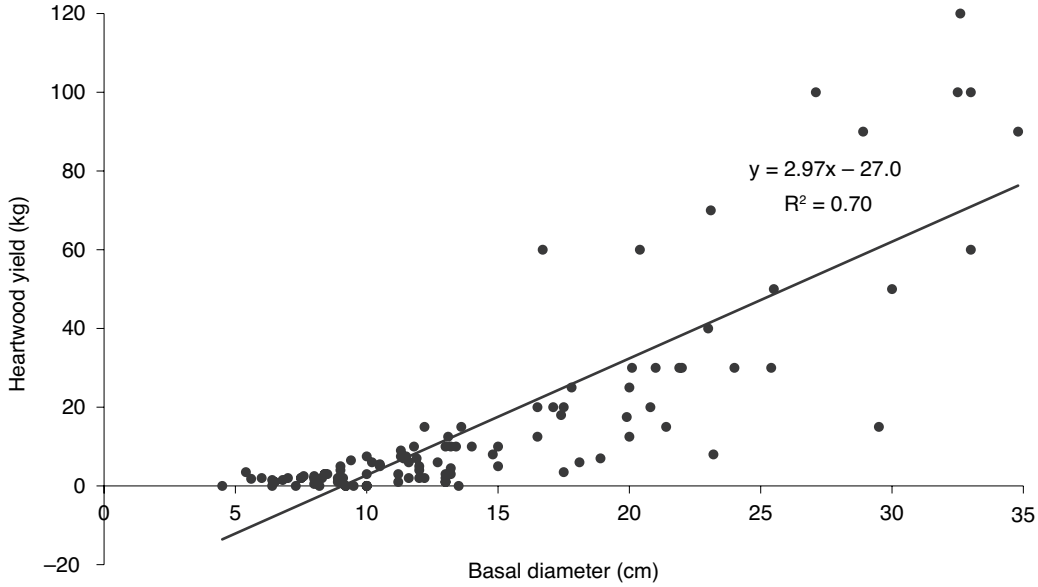

Figure 13. Relative weight of heartwood among sandalwood with different basal diameters, sampled in Tanna and Erromango

weedy vine *Glycine*. Many smallholder plantings are also small (<1 ha) and are likely to benefit from roots growing onto the site from adjacent natural vegetation. Consequently, the spacing recommended for smallholders in Vanuatu is based on a minimum grid of 3 m × 4 m, with long-term hosts occupying spaces on the grid and intermediate hosts planted in between. Such densities are much higher than the 10 m × 10 m spacing recommended by Thomson (2006). Thomson, however, recognised that density varies considerably between different planting types, and we propose that spacings substantially wider than 3 m × 4 m would be required in more industrial-type plantings where ground vegetation is managed more intensively and plantings are larger, thus reducing the presence of suitable host roots from adjacent natural vegetation. Further scientific evaluation of host relationships is required to determine how dependent *S. austrocaledonicum* is on its hosts. It is, however, likely that productivity and profitability would be improved by the inclusion of long-term host-tree species such as *Acacia spirorbis*, *Casuarina equisetifolia*, *Adenanthera pavonina*, *Pterocarpus indicus*, *Hibiscus tileaceous* and *Citrus* species.

The planting of the recommended host trees *Acacia spirorbis*, *Pterocarpus indicus* and *Adenanthera pavonina* may also provide an economic and/or livelihood benefit to the producer through the harvesting of timber products. Each of these species can produce timber of commercial value on the local market, although the rotation of each species is estimated to be over 25–30 years. If these hosts are pruned early to produce a clear, straight bole, then they may provide dual benefits by being a long-term host for one or two sandalwood rotations and a commercial product on final commercial maturity of these trees.

The planting of citrus species is of particular interest since they are known to be good hosts, and the fruit can provide a potential food source and/or income stream from the end of the gardening period to the harvest of the sandalwood. Citrus varieties such as mandarin, orange, lime, lemon and pamplemousse/pomelo have ready village and urban-based markets. The economic modelling in this study included only short-term vegetable crops, but it is likely that the planting of citrus and/or other indigenous nuts and fruits will improve the overall livelihood benefits through food and/or cash.

Socioeconomics of sandalwood production

The Vanuatu sandalwood industry has the potential to develop a niche market based on the organic and sustainable production of a highly valued natural product, which benefits smallholder producers. Like many forestry investments, the planting of sandalwood is a medium- to long-term venture (e.g. commercial Indian sandalwood plantings in Australia are expected to mature approximately 15 years from planting) (ITC 2009; TFS 2009). A 7-year sandalwood rotation for the production of sapwood, which can be used as an alternative filler in many agarbatti products, has been raised as an option for commercial smallholder production.

The objective of this study was to determine current sandalwood planting activity by smallholders in Vanuatu and assess the financial costs and benefits of sandalwood cultivation under three different planting models, relative to existing swidden agricultural practice.

Sandalwood smallholder interviews

Detailed interviews were held in July 2008 with 25 sandalwood producers from a range of socioeconomic classes (Box 1). These growers represented six different islands (Santo, Pentecost, Malekula, Efate, Erromango and Tanna) across Vanuatu.

A total of 206 questions covered the following seven broad topics: (i) land area and use, (ii) nursery management, (iii) site selection, plantation establishment and management, (iv) incidence of pests and disease, (v) marketing, (vi) level of investment, and (vii) input costs of garden and sandalwood farming systems. The responses to the socioeconomic questions were used to determine the average inputs and the financial returns from eight planting scenarios:

- Scenario 1: smallholder garden (1 ha) with staple vegetables worked over a 4-year rotation.
- Scenario 2: commercial smallholder garden (as in scenario 1) interplanted with sandalwood at a density of 3 m × 4 m (833 trees/ha) with 50% harvested at 15 years and the remaining at 20 years for heartwood.
- Scenario 3: sandalwood planting (1 ha) at a density of 3 m × 4 m (833 trees/ha) with 50% harvested at 15 years and the remaining at 20 years for heartwood.
- Scenario 4: sandalwood planting (1 ha) at a density of 2.5 m × 2.5 m (1,600 trees/ha) with all trees harvested at 7 years for sapwood.
- Scenario 5: sandalwood planting (1 ha) at a density of 3 m × 4 m (833 trees/ha) established each year for 10 years. Harvesting of each annual sandalwood planting for heartwood occurs at 15 years (50% of trees) and 20 years (50%). The sandalwood plantings at years 1, 4 and 8 are accompanied with a garden, and each is worked over a 4-year rotation.
- Scenario 6: sandalwood planting (1 ha) at a density of 3 m × 4 m (833 trees/ha) established each year for 10 years. Harvesting of each annual sandalwood planting for heartwood occurs at 15 years (50% of trees) and 20 years (50%).
- Scenario 7: sandalwood planting (1 ha) at a density of 3 m × 4 m (833 trees/ha) with all trees harvested for heartwood at 15 years, followed immediately with another sandalwood planting (1 ha) of equal density and rotation.
- Scenario 8: sandalwood planting (1 ha) at a density of 3 m × 4 m (833 trees/ha) with all trees harvested for heartwood at 30 years.

Economic analysis

A cost–benefit analysis was undertaken to determine the relative economic benefits for smallholders of the seven sandalwood planting models and a smallholder commercial garden on a single plot of land. Labour demands in each of the scenarios are highest in the first 4 years. In all scenarios, the smallholder would have completed the most significant part of the investment in 4 years and would engage in other activities. The economic comparisons between the planting models with shorter (scenarios 1 and 4) and longer (scenarios 2 and 3) rotations reflect the

Box 1 Socioeconomic categories of sandalwood producers interviewed in July 2008

Smallholder: Planting established and managed by a local ni-Vanuatu landowner living with subsistence agriculture.

Employed: Planting established and managed by local ni-Vanuatu on their own land, but employed in another industry.

Local joint-venture: Planting established through a partnership between employed local ni-Vanuatu, that provides capital and/or planting material for a planting, and a smallholder (usually a relative of the other partner) that manages the planting on custom land.

International joint-venture: Planting established and managed by a smallholder providing labour and customary land, but supported by a foreign investor providing capital for the establishment and management of the planting.

Investor: Planting established and managed by foreign interests on leasehold land, employing local labour and expertise.

potential costs and benefits of a single investment on a given plot of land. Many smallholders already work gardens without sandalwood, and the aim of the analysis was to determine (a) if including sandalwood during garden establishment (agroforest) would be of added economic value and (b) if the sandalwood agroforest was comparable to planting sandalwood exclusively (i.e. for sapwood or heartwood). The high density (2,500/ha) required for sapwood plantings naturally excludes any opportunity for smallholders to establish a garden simultaneously on the same site.

Estimates of heartwood yield in both 15- and 20-year-old *S. austrocaledonicum* were conservative. According to our linear regression, trees of such age should yield close to 20 kg and 33 kg of heartwood, respectively (Figure 12). We decided to base our economic modelling for both rotation lengths on the average estimated heartwood yield in the 15-year-old trees sampled, which was 18 kg per tree. This estimate also corresponds to a tree with a basal diameter of 15 cm (Figure 13), which more or less corresponds to a 15-year-old tree growing with an annual basal diameter increment of 1 cm. The price of heartwood was based on the minimum price paid to landowners in 2009, which was 800 vatu (US$1 = 101.17 vatu), with a 20% premium for the use of seed derived from selected clones (Page et al. 2010). During the 4-year growing period, the labour input was assumed to be 33% greater in the garden with sandalwood than in the garden without sandalwood. Fencing costs were not allocated to the garden without sandalwood, as typically household gardens are unfenced. Costs for transporting materials to the planting site were not included in either scenario, because they were highly variable depending on the site's location relative to the village and the local market.

All products were valued at 2009 market prices regardless of whether they were consumed or sold. The garden was assumed to operate for 4 years before soil nutrients were exhausted, although in reality this period would vary considerably between sites, depending on soil fertility at the start of the project. In the smallholder garden interplanted with sandalwood, trees are planted at the same time as the food crops and, when the garden is abandoned to fallow, the natural vegetation re-establishes around the sandalwood, forming an agroforest. It is anticipated that sandalwood growth rates in these agroforests will be highly variable. Consequently, it is assumed that only half of the trees will be harvestable (roots, butts and trunks) in 15 years. The less productive trees will be allowed to remain on the site until year 20, when they will be removed for sale. It is anticipated that the heartwood yield for both harvesting periods will be similar (18 kg/tree). To simplify the comparison between sandalwood heartwood plantings with two 15-year rotations (scenario 7) and a single 30-year rotation (scenario 8), the mean heartwood yield per tree (18 kg at 15 years and 57 kg at 30 years), was used across all trees. Variation between trees is also likely between these two scenarios, and readers are encouraged to consider this in making investment decisions based on information in this report.

All input costs were expressed on a per-hectare basis in Vanuatu vatu and converted into US$. Labour inputs for all scenarios were costed against the average daily wage of 1,000 vatu. Comparisons between scenarios are based on a net present value (NPV) of returns per hectare and labour (per person per day) at a 10% discount rate, internal rate of return (IRR) and benefit:cost ratio (BCR) using the assumptions outlined in Table 4.

Value of sandalwood production and proportion of income

Between 2005 and 2007, the Vanuatu economy grew at approximately 6% per annum, which was a dramatic improvement over the approximately 2% per annum between 1990 and 2004 (AusAID 2008). This growth was driven largely by an increase in international tourism, with the number of arrivals between 2002 and 2007 growing at approximately 11%. However, little growth in agricultural productivity was achieved in rural areas of Vanuatu (Fleming 2007; Reddy 2007), where approximately 75% of the people reside (VNSO 2009). The rural population is young (34% aged under 14) and growing at an annual rate of 2.3%. An increase in rural employment opportunities is required to reduce urban migration and to limit the potential for civil tension. Improvement in agricultural productivity and household livelihoods may be achieved through adapting farming systems, incorporating improved cultivars and domesticating new crops (Tchoundjeu et al. 2010). Bond (2006) identified sandalwood oil as a high-value and low-volume product for development as a long-term cash crop for Pacific island countries. However, continued uptake depends on sandalwood plantings yielding higher financial returns than alternative activities.

A notable limitation to commercial sandalwood plantings is the long rotation relative to many agricultural crops. The minimum period before harvesting is estimated to be between 15 years (for good sites under good management) and 30 years (for less appropriate

Table 4. Socioeconomic assumptions associated with the garden and sandalwood agroforestry models

Socioeconomic assumptions	Value
Gardening period	4 years
Sandalwood 'heartwood'[a] rotation (scenarios 2, 3, 5, 6)	50% 15 years, 50% 20 years
Sandalwood 'heartwood' rotation (scenario 7)	2 × 15 years
Sandalwood 'heartwood' rotation (scenario 8)	30 years
Sandalwood 'sapwood'[b] rotation	7 years
Heartwood yield at 15 and 20 years	18 kg/tree
Sapwood yield at 7 years	25 kg/tree
Heartwood yield at 30 years	57 kg/tree
Farm-gate heartwood price	1,000 vatu (US$9.88)[c]
Farm-gate sapwood price	50 vatu (US$0.49)
Sandalwood density for 'heartwood' (3 m × 4 m plot)	833 trees/ha
Sandalwood density for 'sapwood' (2 m × 2 m plot)	2,500
Price of sandalwood seedlings	200 vatu/seedling
Discount rate	10%
Sandalwood planting	35 seedlings/person/day
Working day	7 hours
Working week	5 days
Working year	45 weeks
Daily wage	1,000 vatu (US$9.88)
Fertiliser application in years 1–4	50 g/plant
Number of 'heartwood' trees harvested and processed per day	1
Number of 'sapwood' trees harvested and processed per day	10

[a] 'Heartwood' refers to the long rotation (15 and 20 years) planting for heartwood.
[b] 'Sapwood' refers to the short rotation (7 years) planting for sapwood.
[c] 1 US$ (American dollar) = 101.17 VUV (Vanuatu vatu) on 2 August 2008.

sites). The production of sandalwood on a shorter rotation for sapwood is not economically competitive with sandalwood agroforestry at both 15 and 30 years (Figures 14 and 19). Given the ambitious stocking rate of 2,500/ha and the low current farm-gate sapwood prices (US$0.49/kg), the short rotation production of sandalwood is marginal when considering it as an option to improve cash flow. The inputs for site preparation and annual management are the same for sapwood production as for the longer rotation sandalwood plantings (scenarios 1 and 2). Although sapwood production (scenario 4) has reduced pruning inputs and pest control measures, the cost of planting and fertilising 2,500 stems/ha (US$7,167) is considerably higher than for the 833 stems/ha ($2,707) in scenarios 2–3 and 5–8.

Labour requirements

With an average of five individuals in a smallholder household (VNSO 2007), most of the labour associated with the production models would be carried out by members of the family. Although smallholders would generally not pay individual family members for their inputs, these costs were included in all production models. Sourcing labour outside the family unit was not an issue for any of those interviewed, but capital for paid labour was not available for 70% of smallholder respondents and was a major constraint on the development of larger (>1 ha) plantings.

Capital inputs

The capital inputs will vary considerably between planting sites, but potential inputs across all sites were included in the models. Given the high palatability of sandalwood leaves, fencing would be essential in areas with feral or untethered cattle. The threat of pests and diseases for sandalwood in Vanuatu is quite low. Sap-sucking insects and leaf fungal disease can be an issue for humid sites at certain times of the year, particularly with younger saplings, but are not a serious problem at present. Although these pest issues are likely to affect growth, they are not likely to cause tree death. The use of chemicals to control such pests is therefore not necessary to ensure plantation survival and is unlikely to be used. The most significant biological disease of sandalwood is *Phellinus noxius* (brown rot, locally known as navwun), which attacks the tree roots. The disease can rapidly spread within a sandalwood planting and has the potential to kill trees. The use of fungicides to control the disease is expensive and largely untested. Appropriate site selection and hygiene are the two most important factors to limit the ingress of pests. Although capital inputs such as fertiliser and pesticides are unlikely to be used by smallholders, these costs have been included in the sandalwood financial models to ensure that they, or other cost-competitive organic options, can be accommodated within the budget if they are required.

Comparative system profitability

The profitability of different scenarios may be compared among those of equivalent investment periods. However, because of the variable maturation of the different crops, such as garden plants and sandalwood, it is not possible to make each investment/scenario cover the same period. The aim of this study was to determine if it was of economic value for a smallholder to plant sandalwood, both by itself and within a garden. Therefore, the establishment of another five gardens and three sapwood plantings to attain approximately equal 20-year rotations was viewed as a separate investment to the original plantings. These separate investments would therefore also need to be included in the 15- or 20-year sandalwood rotations (scenarios 3 and 4). This type of economic analysis of reinvestment was considered to be beyond the aim of this report. Furthermore, it was not considered valid to compare three garden rotations with one sandalwood rotation, because we assumed that the major effort and investment period for sandalwood would fall within the garden rotation (i.e. 4 years during establishment) and the final years (during harvest and marketing). We have separated our eight scenarios for comparison of profitability into those with (a) a single investment (one planting) with a total rotation of 20 years or less (scenarios 1–4), (b) multiple plantings (scenarios 5 and 6) and (c) investments with a total rotation of 30 years (scenarios 7 and 8).

Comparisons between garden and sandalwood agroforestry systems over a single rotation (scenarios 1–4)

Based on the assumptions of these scenarios, the production of sandalwood heartwood and sapwood by smallholders in Vanuatu is economically feasible, with positive NPVs for all scenarios at a discount rate of 10% (Table 5). The most profitable activity is the sandalwood agroforest (scenario 2), which combines a 4-year food garden with a 15–20-year

heartwood rotation. This sandalwood agroforest had the highest BCR of all planting scenarios and an NPV that is approximately 13.5 times swidden cropping (scenario 1), 1.5 times that of a pure stand of planted sandalwood harvested for heartwood (scenario 3) and 280 times that of a sandalwood planting harvested for sapwood (scenario 4).

The establishment of a smallholder garden (scenario 1) had the highest IRR (28%), above that of both scenarios involving smallholder heartwood production (scenario 2, 24%; and scenario 3, 16%) (Table 5). This does not necessarily mean that the smallholder garden provides better returns than either of the heartwood plantings, since the heartwood plantings provide an NPV and a BCR that are 9.1–13.5 and 2.0–2.1 times higher, respectively, than the garden. This ambiguous IRR reflects the different period of investment between these scenarios, where the discounting has a disproportionate effect between them. In the smallholder garden, discounting only has an effect over 4 years, compared with 20 years for sandalwood plantings for heartwood (Figure 14).

The economic feasibility of producing sandalwood sapwood is less clear. Although it has a positive NPV, it is only 5% of that for working a garden (scenario 1) over 4 years, and the return to labour (US$1.27/hour) is less than the minimum wage (US$1.43/hour) (Table 5). Given the significant investment in sapwood production and the low NPV relative to both garden and sandalwood heartwood production, it may be considered to be a low-priority commercial activity. Intensive production (2,500/ha) of sandalwood is also untested, and the silviculture of such a density is likely to be problematic since it would preclude inclusion of host trees. Historically, the trade in sandalwood in Vanuatu was restricted to the 'desapped heartwood' and trade in sapwood was prohibited. In an attempt to fully use the harvested resource from natural stands, trade in sapwood, including chips from the cleaning of the heartwood, and branches was permitted. The trade in sapwood led to confusion in the marketplace and harvesting of immature wild trees, which stimulated the reintroduction of restrictions for wild sapwood trade in Vanuatu. The trade in sapwood is also intermittent, so exporters in Vanuatu have had to warehouse large stocks of sapwood until the market becomes available.

The production of sandalwood obviously suffers, as do all forestry enterprises, from cash-flow problems. In common with other examples of

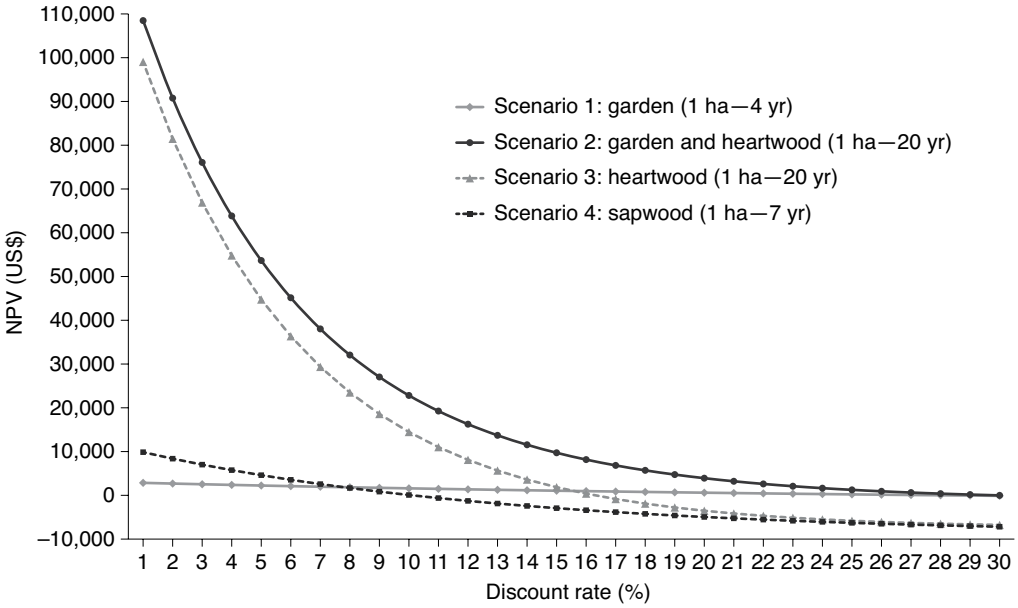

Figure 14. Net present value (NPV) profile for the four different planting scenarios across discount rates from 1% to 30%. The internal rate of return is the discount rate at which the NPV equals zero. The effect of discounting is most pronounced in the two 20-year scenarios (2 and 3).

agroforestry, the combination of cropping activities with tree (sandalwood) production reduces the negative cash flow during the establishment years (Figure 15) to ensure that the enterprise can be maintained until the first significant income when harvest can occur. Sandalwood agroforestry also increases the efficiency of maintenance activities, which benefit both crop and tree compared with crop production alone; this is particularly relevant to the high cost of weeding activities.

The labour inputs associated with weeding in the first 4 years are comparable between all scenarios. Relative to gross receipts, weeding labour is greater in sandalwood plantings without gardens, where it represents 6%, 9% and 14% in scenarios 2 (heartwood and garden agroforest), 3 (heartwood only) and 4 (sapwood only), respectively. Return to labour represents the hourly wage rate that sets the NPV equal to zero at a discount rate of 10%. In the first three scenarios, the return to labour is greater than the minimum wage of approximately US$1.40 (1,000 vt)/day (Table 5). This indicates that smallholders will be financially better off working a garden, a sandalwood agroforest or sandalwood planting than undertaking off-farm employment that attracts the minimum wage. The return to labour for the sandalwood agroforest (scenario 2) is US$4.70/hour, which is equivalent to the average hourly rate for a Technician (CS2.2) employed by the Vanuatu Government. Such a position typically requires an education equivalent to that of a technical college diploma. Although the NPV of scenario 3 is less than that of scenario 2, it has a higher return to labour (US$5.74). The lower return to labour in scenario 2 results from the higher labour requirements for the work associated with the garden.

Comparisons between garden and sandalwood agroforestry systems over a single rotation established every year for 10 years (scenarios 5 and 6)

The scaling up of sandalwood plantings in Vanuatu is feasible for a cohesive family unit, or an individual with capital that is dedicated to establishing approximately 1 ha of planted sandalwood per year for 10 years. This type of planting has already been demonstrated in south-west Malekula (Palen et al. 2008) where four 'brothers' and their families have established 9,173 sandalwood trees over 10 consecutive years from 2001 to 2010 (Kaising et al. 2010). These models may also be suited to joint-ventures as discussed previously, whereby capital can be used to employ labour to assist with the clearing, planting and maintenance costs, which would typically

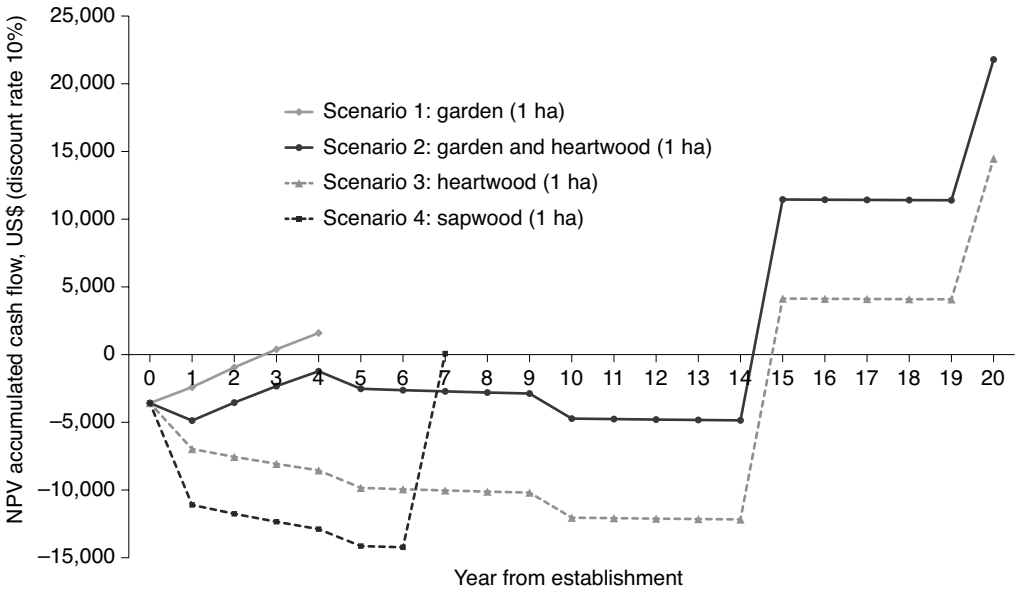

Figure 15. Net present value (NPV) accumulated cash flow for four 1-hectare planting models

be beyond an individual smallholder farmer. By undertaking joint-venture projects in this way, the investor can build the relationship necessary with fewer farmers, which is much easier to manage than having many different joint-venture partners. The disadvantage of this model obviously exists in the long-term investment cycle.

In scenario 5, a new garden is established every 4 years for three cycles with the newly planted sandalwood for that year. Gardening after year 12 is considered to be beyond the scope of the original investment and is therefore not included within this planting model. The economic feasibility of these two 10 ha planting models is similar for that of only 1 ha, where it is more profitable to establish sandalwood with a garden (NPV~US$159,379.55) than to plant sandalwood alone (NPV US$143,454.04) (Figure 16). The IRRs of both scenarios 2 (24%) and 3 (16%) (Figure 14) are increased when scaled up as in scenarios 5 (25%) and 6 (21%), respectively (Figure 17). Results of this economic analysis indicate that scaling up a sandalwood planting is a worthy activity for a smallholder family.

Interestingly, the NPV of scenario 5 is not a direct multiplier of the equivalent 1 hectare scenario 2 (Table 5). This is largely because a new garden is not established every year and therefore the relative economic benefits of the garden are reduced compared with the 1 hectare planting. Scenario 6 is essentially identical to scenario 3 but on a larger scale (multiplied by 10 years); therefore the NPV of scenario 6 is approximately 10 times larger than that of scenario 3 (Table 5).

Comparisons between sandalwood agroforestry systems over a single rotation of 15 years (scenario 7) and 30 years (scenario 8)

It is important to determine the optimum time to harvest a sandalwood planting. There is an obvious positive relationship between tree age and heartwood volume, and therefore the longer a tree is left to grow the greater its potential value. Although the relationship between tree age and heartwood weight appears to be linear, only very limited heartwood can be found in a tree under the age of 10 years (Figure 12). After the development of heartwood begins, the weight of heartwood increases at approximately 2.5 times the rate of time. The estimated weight of heartwood in a 30-year-old tree (57 kg) is more than three times that of a 15-year old tree (18 kg); however, it is only twice its age. It is therefore of interest to compare the economic benefits of producing sandalwood over two 15-year rotations (scenario 7) with a combined mean heartwood weight of 36 kg/tree, with a single

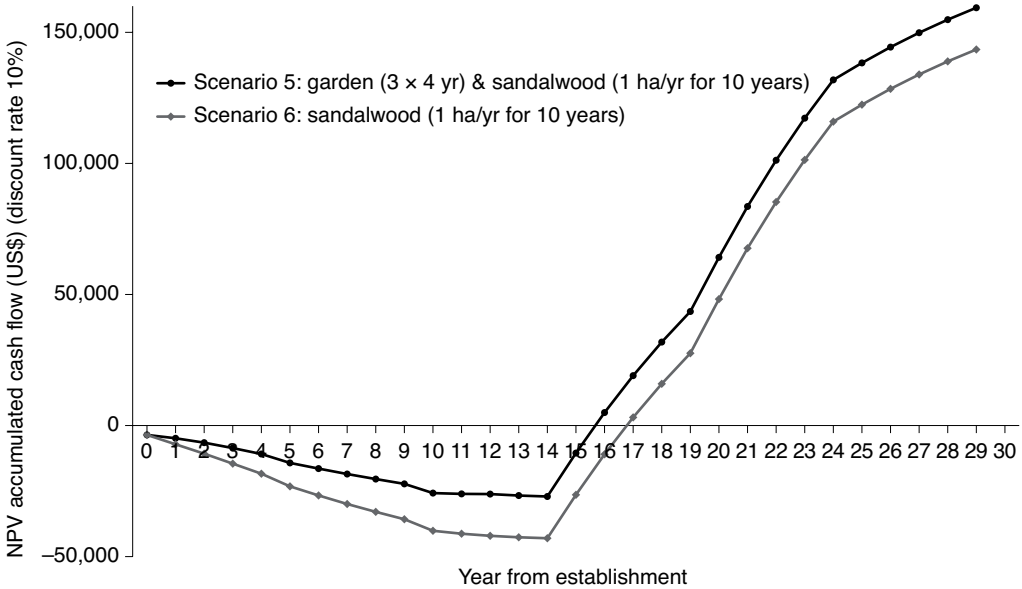

Figure 16. Net present value (NPV) accumulated cash flow for two 1 hectare planting models at a 10% discount rate

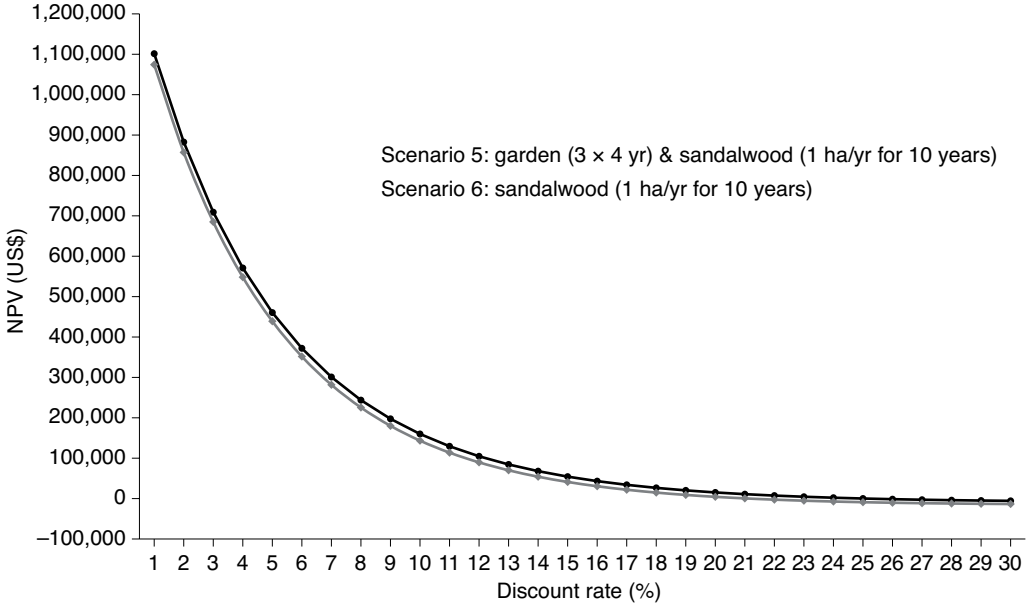

Figure 17. Net present value (NPV) profile for two different planting scenarios across discount rates from 1% to 30%. The internal rate of return is the discount rate at which the NPV equals zero.

30-year rotation (scenario 8) with a mean heartwood weight of 57 kg/tree.

It was found that, while a greater weight of heartwood per tree was gained in the single 30-year rotation than in the two 15-year rotations, the NPV of the former was substantially lower (scenario 8, US$20,311) than the latter (scenario 7, US$35,833) (Figure 18), despite the higher costs of establishing two plantings in scenario 7 compared with only one in scenario 8. The difference in the NPV between these scenarios was caused exclusively by the increased impact of discounting on the longer rotation scenario. The differential effect of discounting on these two scenarios is demonstrated by the higher NPV for the 30-year scenario 8 compared with the two 15-year scenarios 7 at discount rates of below 6% (Figure 19).

The comparison between scenarios 7 and 8 only valued the trees according to the weight of heartwood and the farm-gate value of approximately US$10/kg. It is likely, however, that the trees growing within the 30-year rotation have a much higher chance of producing carving logs than those in the two 15-year rotations. The minimum specification of a carving log is set at a diameter of 10 cm of pure heartwood at the smallest end of the log. If a 15-year-old tree has a basal diameter (under bark) of approximately 15 cm, with about 50% of the stem cross-section comprised of heartwood, then the diameter of the heartwood at the base would be about 10.5 cm. Given that this is at the widest end of the log, it would be unlikely that any of the 15-year-old trees would have heartwood that meets the minimum specifications for a carving log. Trees in the 30-year rotation, however, may have an under-bark basal diameter of 30 cm and, with 50% of its basal area comprised of heartwood, could have a heartwood diameter of 21.3 cm. For the sandalwood trees measured in this study, the diameter at breast height was, on average, 76.4% of the basal diameter (stem taper). If the heartwood percentage is consistent along the stem, the diameter of the heartwood at breast height would be approximately 16.3 cm.

Provided that appropriate pruning occurred at an early age (as costed in all scenarios), all 30-year-old trees have the potential to produce a carving log to meet the highest specifications (i.e. clear grain heartwood with no faults or cracks, with a minimum diameter of 10 cm at its narrowest end and a length of 1.2 m). Although the potential exists, it is likely that many trees in the planting would not meet the specifications as, for example, a proportion of the trees may have windswept trunks or rot.

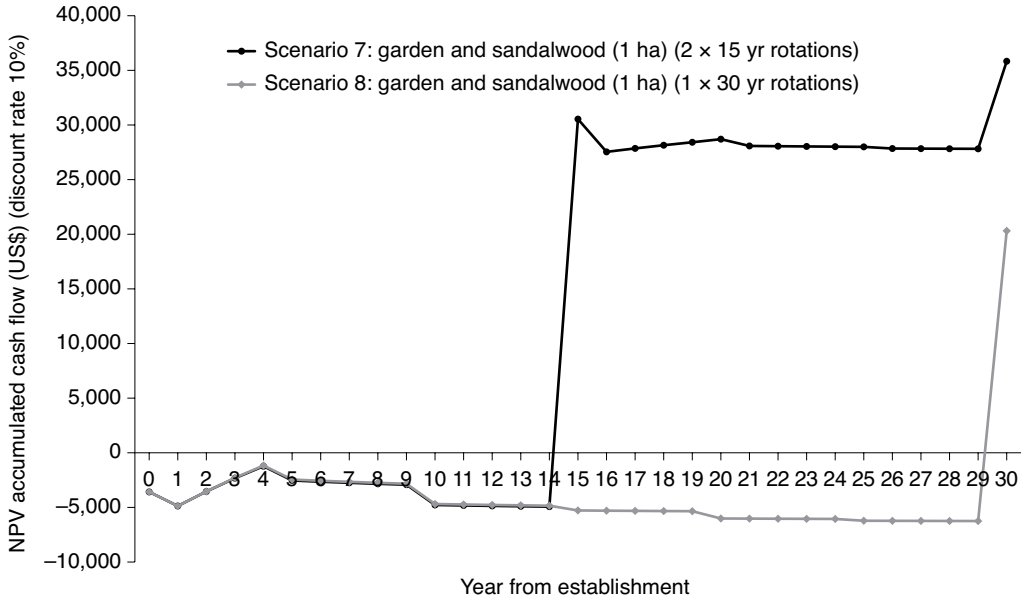

Figure 18. Net present value (NPV) accumulated cash flow for two 1 hectare planting models at a 10% discount rate

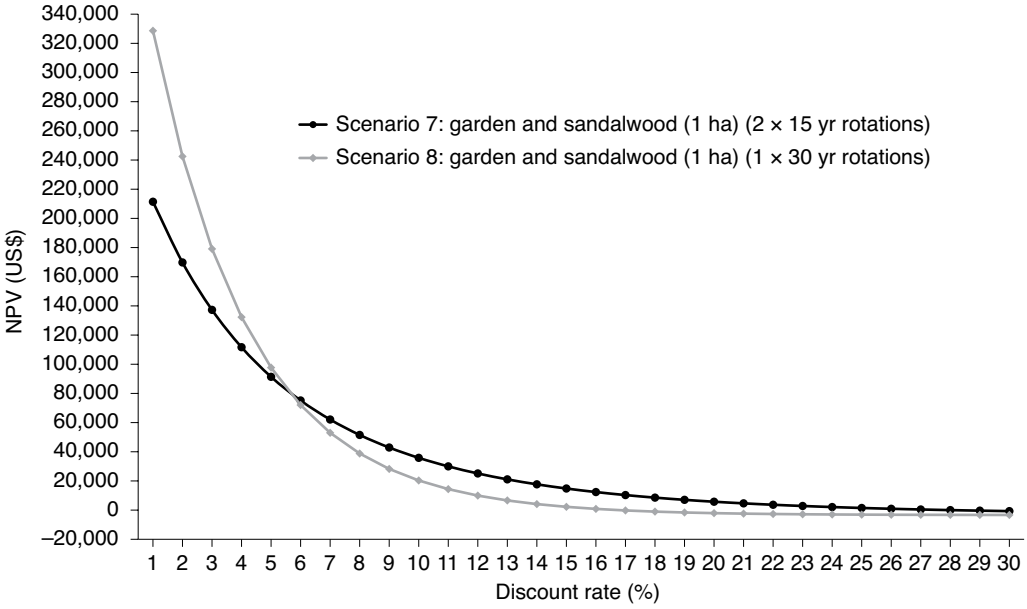

Figure 19. Net present value (NPV) profile for two different planting scenarios across discount rates from 1% to 30%. The internal rate of return is the discount rate at which the NPV equals zero.

Table 5. Comparison of the income, costs and profits of eight different planting models

Summary (NPV format)	US$/hectare/year[a]							
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
	Garden (1 ha)	Garden and sandalwood heartwood (1 ha)	Sandalwood only (1 ha)	Sandalwood sapwood (1 ha)	Garden and sandalwood (10 ha)	Sandalwood only (10 ha)	Garden and sandalwood (1 ha)	Garden and sandalwood (1 ha)
	4 yr	4, 15, 20 yr	15, 20 yr	1 × 7 yr	4, 15, 20 yr	15, 20 yr	2 × 15 yr	1 × 30 yr
Sandalwood gross receipts	–	$28,754.61	$28,754.61	$15,850.74	$194,353.07	$194,353.07	$14,878.83	$27,037.55
Garden gross receipts	$12,219.51	$12,219.51	–	–	$26,266.08	–	$14,878.83	$12,219.51
Total gross receipts	*$12,219.51*	*$40,974.11*	*$28,754.61*	*$15,850.74*	*$220,619.15*	*$194,353.07*	*$58,851.63*	*$39,257.06*
less average variable costs of:								
– land preparation and planting	$249.66	$2,467.50	$2,467.50	$6,489.79	$16,945.25	$16,945.25	$3,058.21	$2,467.50
– weed control	$1,871.45	$2,553.13	$2,553.13	$2,221.12	$17,260.91	$17,256.67	$3,110.17	$2,566.84
– pruning	–	$120.83	$120.83	–	$476.70	$476.70	$152.65	$57.00
– fertiliser	–	$239.48	$239.48	$678.13	$1,618.67	$1,618.67	$296.81	$239.48
– pest and disease control	–	$383.03	$383.03	$226.81	$1,023.22	$1,227.00	$524.41	$516.80
– irrigation	–	$18.73	$18.73	$18.73	$126.60	$126.60	$23.66	$18.73
– harvesting	–	$1,620.49	$1,620.49	$1,473.88	$5,517.48	$5,517.48	$2,296.36	$478.66
– gardening	$4,903.47	$4,903.47	–	–	$10,540.11	–	$5,970.61	$4,903.47
Total average variable costs	*$7,024.58*	*$12,306.67*	*$7,403.20*	*$11,108.47*	*$53,508.96*	*$43,168.39*	*$15,432.87*	*$11,248.49*
Gross margin (receipts – variable costs)	$5,194.93	$28,667.44	$21,351.41	$4,742.27	$167,110.19	$151,184.68	$43,418.76	$28,008.57
Capital purchases	$3,601.75	$6,881.80	$6,881.80	$4,665.29	$7,730.64	$7,730.64	$7,585.03	$7,696.85
Total fixed costs	*$3,601.75*	*$6,881.80*	*$6,881.80*	*$4,665.29*	*$7,730.64*	*$7,730.64*	*$7,585.03*	*$7,696.85*
Total costs	*$10,626.33*	*$19,188.47*	*$14,285.00*	*$15,773.76*	*$61,239.60*	*$50,899.02*	*$23,017.90*	*$18,945.33*
Farm profit	$1,593.18	$21,785.64	$14,469.61	$76.97	$159,379.55	$143,454.04	$35,833.73	$20,311.72
Internal rate of return	0.28	0.24	0.16	0.10	0.25	0.21	0.28	0.17
Benefit:cost ratio	1.15	2.14	2.01	1.00	3.60	3.82	2.56	2.07
Return to labour	1.76	4.70	5.74	1.27	7.64	9.33	6.02	4.98
NPV relative to scenario 1	1.00	13.67	9.08	0.05	100.04	90.04	22.49	12.75

– = not applicable; NPV = net present value

[a] Figures are all in US$ based on the exchange rate of US$1 = 101.17 vatu on 2 August 2008 at a discount rate of 10%.

The data used to determine the size of the trees at ages 15 and 30 years were for trees grown under existing smallholder-managed systems with a mean annual basal increment of approximately 1 cm. With trees managed more intensely under commercial conditions, the mean annual basal increment of 1.8 cm was significantly ($P < 0.05$) greater than for smallholder systems. Given that all trees measured under commercial conditions were 3 years old or less, it may be expected that these growth rates would decrease. It is likely that trees managed more intensively would attain a greater size by year 15, compared with a smallholder system. It is not, however, possible to predict the influence of a more intensive management system on the development of heartwood in *S. austrocaledonicum*.

Sandalwood markets and marketing

The full scope and value of the international sandalwood market is very difficult to accurately gauge due to commercial secrecy and illegal trade in the global sandalwood market (AAG 2006; Clarke 2006; Adviser Edge 2008). A concerted effort was made to seek data from a variety of published sources, government departments and regulators, and sandalwood traders; however, much of the data, particularly of market volumes and the prices obtained, is indicative only.

Sandalwood quality

The valuable fragrant oils of the sandalwood tree are concentrated in its heartwood. The market value of a given volume of heartwood will depend primarily on the concentration and quality of its oil. The oil consists of a range of different compounds (Alpha et al. 1997a, 1997b; Moretta 2001; Braun et al. 2005; Doran et al. 2005, 2007; Jones 2005; Jones et al. 2006), but the quality of sandalwood in the marketplace is typically determined by the relative proportions of α- and β-santalol as recognised in the international standard for Indian sandalwood (*Santalum album*) oil (ISO 3518:2002). Heartwood oil concentration and quality in sandalwood vary between species and can also be influenced by genetic, environmental and agronomic factors.

Indian sandalwood has the highest average heartwood oil content of the major commercial sandalwood species (Table 6). The high oil content and the high levels of santalol in Indian sandalwood result in a strong demand for, and a high value of, this species. The comparative heartwood oil concentration of sandalwood from Pacific islands generally lies somewhere between Indian and Australian sandalwood.

Despite the lower quality of the oil extracted from Australian sandalwood compared with Indian sandalwood, Australian sandalwood oil is still accepted as an important product in the fragrance market, and a large volume of it is purchased by perfume manufacturers at a discounted price. Significant volumes are also purchased by the Indian tobacco industry to flavour chewing gum (AAG 2006). This type of activity illustrates the very diverse nature of the international sandalwood market from both a product development and market segmentation perspective.

While carving or ornamental logs attract the highest prices, they are quite rare, and there is currently very little wood entering these markets, due primarily to the historical overexploitation and the current practice of harvesting immature trees.

Relative value of sandalwood products

All prices listed in this section are for 2008–09 and applicable where the seller bears the cost of insurance and freight to bring the goods to the port of destination. The prices of carving logs are generally dependent on the species, with *S. album* commanding the highest prices in the market (US$74/kg) given its reputation for high oil concentration and quality (Table 7). The value of the *S. yasi* carving log is about 60% of *S. album*. While modest volumes of *S. macgregorii* are traded internationally, most enters through unofficial channels, and the price is difficult to track. However, based on its relatively good oil quality (Doran et al. 2007), its value is likely to be similar to that of *S. austrocaledonicum*.

Oil prices are highly dependent on the santalol levels of each species, but significant variation can be found depending on tree age, genotype and environment. The relative 2008 prices for oil reflect the mean level of santalol for each species, with the highest being *S. album* (Table 7), while no oil production has been recorded for *S. lanceolatum*. Pre-grind heartwood, typically used for oil extraction, is priced on a similar basis to both carving logs and oil, reflecting both the santalol levels and the yield potentials of each species (Table 7).

The balance of the remaining sandalwood goes into the agarbatti industry to be powdered and made into incense and other products for burning. This part of the industry is highly price sensitive (elastic demand), and

Table 6. Comparison of sandalwood oil content

Species	Origin	Oil content (%)
S. album	India, Indonesia	6–7
S. yasi	Fiji	5
S. austrocaledonicum	Vanuatu, New Caledonia	3–5
S. spicatum	Western Australia	2
S. lanceolatum	Queensland	1

Source: AAG (2006)

Table 7. Price for sandalwood products from different sandalwood species

Product	Price (US$/kg)[a]					
	S. album	*S. yasi*	*S. austrocaledonicum*	*S. spicatum*	*S. lanceolatum*	*S. macgregorii*
Carving log	74	44	38	13	6	na
Oil	1,250	1,050	950	700	–	na
Pre-grind heartwood	40–45	30	29	10	3	na

– = not applicable; na = not available

[a] Prices are for 2008–09.

the greater the level of santalol in the powder the higher the price and size of the market. The upper end of the agarbatti powder market is about US$18/kg, and the lower end is about US$1.20/kg for spent charge (wood residue after most oil has been extracted). Substitution is prevalent in the agarbatti market and puts pressure on price increases of pure sandalwood products (Cogo 2006). Reputable suppliers of powder need to ensure a consistent supply of powder at consistent quality.

While the proportional value of the species remains somewhat constant, there is great price variation within each species, depending on oil concentration and quality. Therefore, opportunity exists to improve the value of a planted resource through selection of high-quality trees as source planting material. Such initiatives over the long term have the potential to increase the value of a given species to a higher relative position in the market.

Domestic value of sandalwood in Vanuatu

In Vanuatu, the Vanuatu Department of Forests (VDoF) regulates the minimum price paid per kilogram of desapped heartwood for wild-harvested trees. The minimum price is reviewed annually and publicised in a VDoF Service Message issued at the start of the sandalwood-harvesting season. The price paid to villagers is colloquially known as 'beach price' as the harvesters often bring the sandalwood from the forest to the beach, and after a trade is completed the buyer meets all costs for transport to the factory in Port Vila. The minimum price for desapped heartwood has been increasing at an annual rate of 10% since 1990 and 7.5% since 2000, which is substantially greater than the average annual increase in the consumer price index (CPI) for both Australia (2.5%) and Vanuatu (2.6%) across both decades (Figure 20). For high-quality sandalwood consignments, the beach price is also often higher than the minimum price set by the VDoF. Although sandalwood may have been undervalued in the early 1990s, the fact that prices have continued to rise above the average CPI increase since 2000 indicates an increase in demand and/or a decrease in supply beyond that of the general marketplace.

Market demand and price

Current world market demand for sandalwood is thought to be around 5,000–6,000 tonnes per year. This figure incorporates demand for a number of different products, sourced from a variety of sandalwood species. As the gap between sandalwood supply and demand has widened over time, there has been a simultaneous increase in the price of its products (Adviser Edge 2008).

The lack of transparency in the production and marketing of Indian sandalwood means that supply and price trend information is extremely difficult to obtain. The problem in determining price trends is also complicated by the extensive trade in illegal wood, as this harvest is not reported (Adviser Edge 2008).

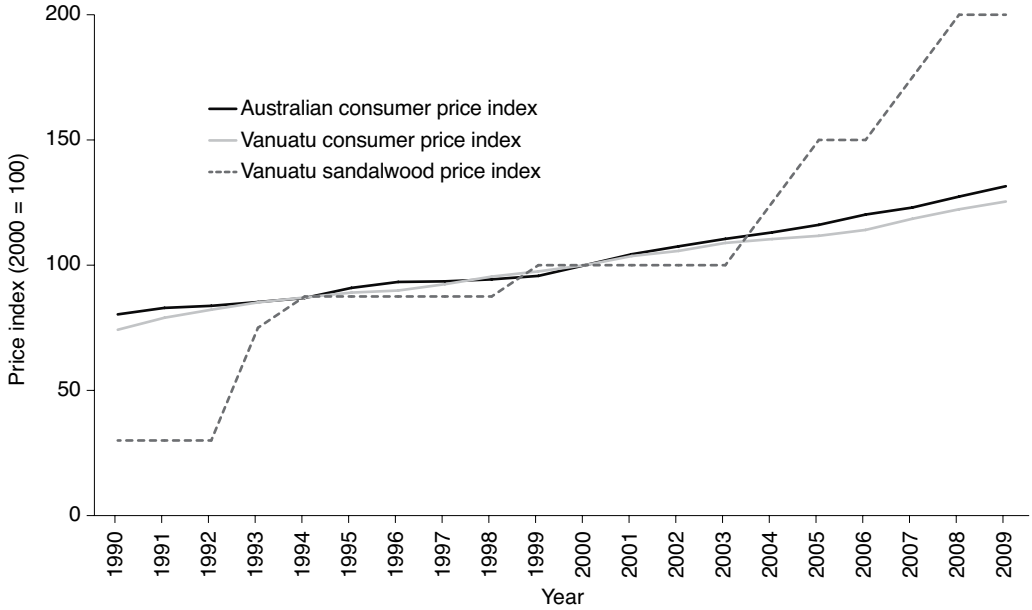

Figure 20. Relative changes in consumer price index and minimum price paid to smallholders for sandalwood heartwood in Vanuatu between 1980 and 2009. Prices are indexed to a unit value of 100 in the year 2000. (Sources: Australian Bureau of Statistics; Vanuatu Statistics Office; Vanuatu Department of Forests Annual Trading Season Announcements)

While native supplies of Indian sandalwood have declined considerably, demand has remained relatively constant, and has pushed the price of the commodity up significantly over the past few years. Legally sourced Indian sandalwood currently trades at between A$30,000 and $85,000 per tonne, with sapwood prices ranging from $1,000 to $2,500 per tonne (Adviser Edge 2008). A 17-fold increase in the price for Indian sandalwood has been recorded since 1990 (Figure 21), which is also reflected in the fivefold increase in price for Indian sandalwood oil in the 7 years from 2001 to 2007 (Figure 22).

The price growth for Indian sandalwood is considered to be unsustainable at its current levels (approximately 23% compounded over 15 years), with a proportion of Indian sandalwood remaining unsold at recent auctions in India (Adviser Edge 2008). The introduction of high-quality synthetics into the market may also reduce the potential for further sandalwood oil price increases.

Over the past 10 years, the price of Australian sandalwood has also continued to increase, indicating an unsatisfied demand for the commodity worldwide. Yet despite the market potential and demand for Australian sandalwood, it still does not attract the premiums of Indian sandalwood. Heartwood prices for Australian sandalwood range between AU$3,000 and $16,500 per tonne (AAG 2006).

Despite recent activity in planting *S. album* and *S. spicatum* in Western Australia, the majority of current product on the market continues to be sourced from natural populations. Due to overexploitation and lack of protection for the resource in many producing countries, India and Australia are the dominant suppliers of sandalwood in global markets (AAG 2006).

Supply and demand challenges

Reliable supply

As sandalwood supply has been constrained, some purchasing companies, including perfume companies, have not been able to obtain the critical mass needed to justify featuring sandalwood in their products. The global fragrance market favours natural products, such as sandalwood, and will therefore prefer these products over synthetic ingredients, but only when a critical mass supply can be guaranteed, at a commercially viable price (Adviser Edge 2008).

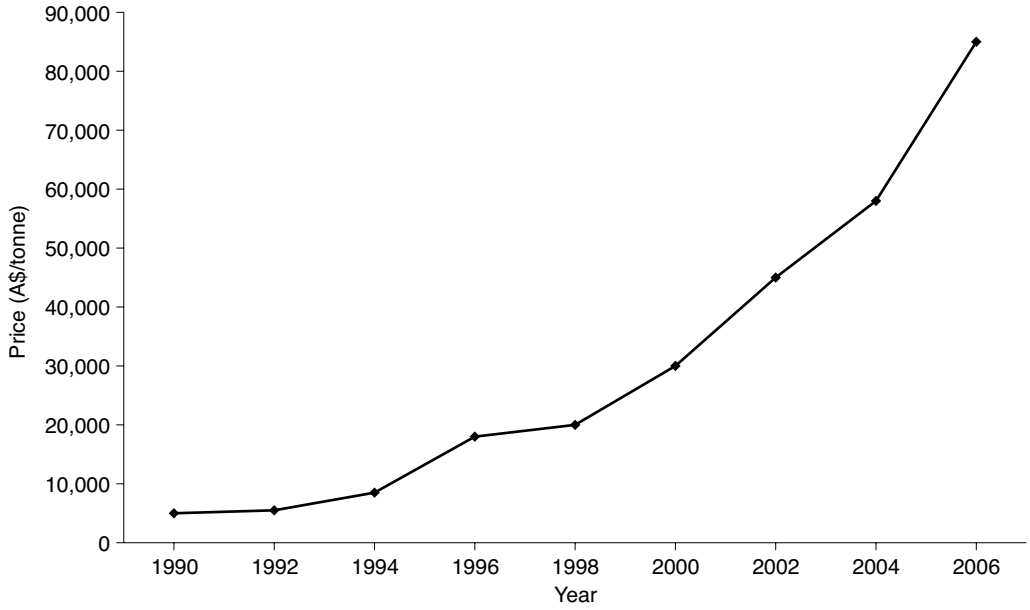

Figure 21. Indian sandalwood auction prices, 1990–2006 (Source: Adviser Edge 2008)

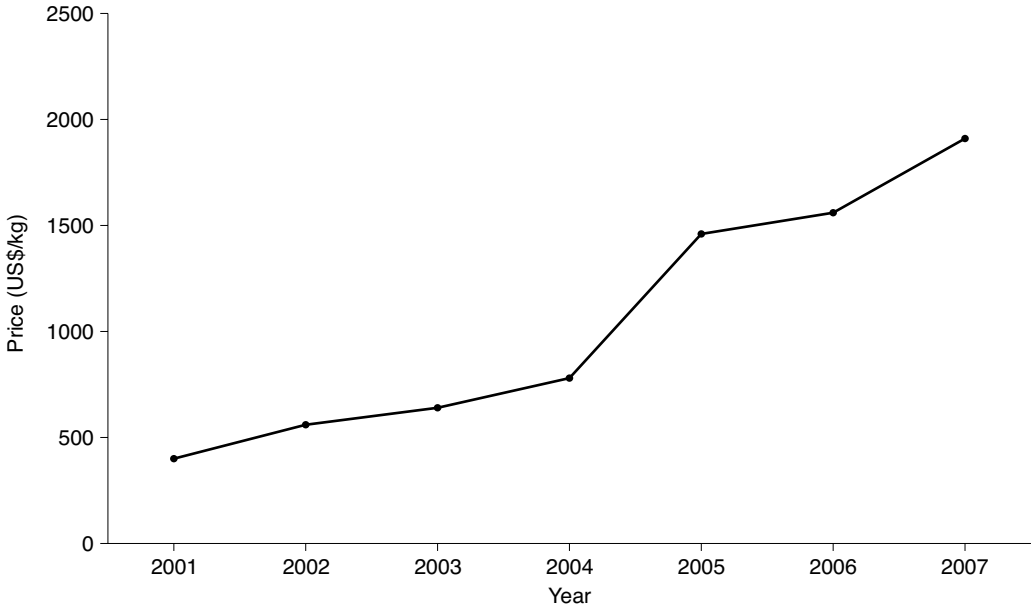

Figure 22. Indicative prices of Indian sandalwood oil, 2001–07 (Source: Tropical Forestry Services)

Therefore, as supply continues to decline over the short term, some markets are likely to be lost. Further engagement with the market in the future would be required to regain these markets for plantation-sourced products.

The reduction in sandalwood supply has also resulted in sandalwood oil being replaced by poorer quality blended oils in the bottom end of the fragrance oil market. This has had a negative impact on buyer confidence and industry credibility (Adviser Edge 2008) and further stresses the need for appropriate certification systems and product standards within the industry.

Substitutes

The supply and demand of sandalwood, and the price of substitute products in the market, will be important factors in influencing market conditions for sandalwood products in the future. Synthetic sandalwood oil can be used in low-cost products such as budget perfumes and cosmetics (Clarke 2006). Although substitutes have previously been developed, markets have differentiated synthetic copies and valued them accordingly (Adviser Edge 2008). These synthetics are likely to limit future price increases for natural products, particularly those of a lower grade.

Plantations

Australia is already a major contributor to the international sandalwood market, harvesting approximately 2,300 tonnes of native Australian sandalwood (*S. spicatum*) in Western Australia. The declining production of Indian sandalwood in India, and the eventual harvest of Indian and Australian sandalwood from Australian plantations should see Australia become the largest global producer by 2020.

By 2021, it is expected that the Australian harvest of Indian sandalwood heartwood could reach 8,800 tonnes per year, while the harvest of Australian sandalwood heartwood is expected to reach 3,195 tonnes per year (Adviser Edge 2008). Given the rapid escalation in Australian production anticipated from 2014 onwards, it will be important for Indian sandalwood and Australian sandalwood plantation managers to continue exploring and developing markets. This will help to mitigate any potential price adjustments that may occur due to increased global supply in the future (Adviser Edge 2008). The increase in global supplies of sandalwood will also affect the pricing and marketing of Vanuatu sandalwood. Differentiation of Vanuatu sandalwood from other plantation products through the use of its local species with high santalol content, organic production and association with poor smallholder farmers will enable it to continue its market niche and limit abrupt downward price adjustments. Failure to adequately differentiate Vanuatu sandalwood products from those of Australia, India and China will lead to direct competition with these suppliers.

Despite the current strong demand for sandalwood in world markets and supply shortfalls, it is uncertain how the international market will react when significant volumes of product come onto the market from Australian and later Chinese plantations. It can be expected that an increased supply will place a downward pressure on prices, but by how much will ultimately depend on the market conditions at the time of sale and the ability of the industry to develop and implement appropriate market strategies (AAG 2006). It is probable that much of the new plantation-derived product will be absorbed by the current unsatisfied markets, but the level of such demand is as yet unquantified.

Sandalwood plantings in the South Pacific islands are much smaller and more widely dispersed than those in Western Australia. Pacific island plantations of sandalwood run considerable risks from tropical cyclones, fire, *Phellinus noxius* fungus, theft and rights of ownership. However, compared with the plantations being developed in Western Australia, Pacific island producers have several advantages, such as more rapid growth and shorter rotations for the production of valuable heartwood, lower inputs (Thomson 2008), lower cost of land and organic production.

It is vitally important that the Vanuatu sandalwood industry develops and implements appropriate industry development and marketing strategies *in advance* of the expected increases in Australian plantation production and clearly differentiates the Vanuatu industry and Vanuatu sandalwood products from larger scale international competitors.

Future demand

Factors influencing demand in 'eastern' markets include increasing prosperity, a growing market and consumer preference for natural products, and significant growth in demand from China. The major commercial end uses of sandalwood in 'western' markets are as a key component in fine fragrances, toiletries, aromatherapy and incense, and as an insect repellent. Factors influencing demand in Western

markets include growing consumer preference for natural ingredients; manufacturer preference for sustainable, ethically produced ingredients; and a growing global beauty industry (Adviser Edge 2008).

Certification schemes and quality standards

Certification schemes

Certification schemes are formal, auditable management systems, commonly used for a myriad key operational purposes, such as sustainable production practices, quality assurance, environmental management, organics, and workplace health and safety. Private or public sector organisations that advertise their compliance with a particular certification scheme will normally have been audited by a qualified independent party as acting in accordance with the stated program.

These schemes are becoming increasingly important within the forestry and essential oil industries and impact on both small-scale and large corporate businesses. Implementing certification schemes can 'prove' that a business complies with defined management systems—for example, sustainable production and harvesting practices—or illustrate equitable arrangements with Indigenous communities. Certification schemes will often provide transparency and allow traceability of product throughout the supply chain, and hence enhance buyer confidence in a supplier's capability.

Although used primarily for compliance purposes, certification schemes can be used commercially as marketing tools to illustrate a company's or supply chain's 'positive points of difference' relative to the competition. Certification schemes can also be used to promote companies as ethical, environmentally responsible and 'good corporate citizens', and hence attract consumer and investor support.

Certification schemes can be developed at the national or community level. AusAID reports that non-government organisations and other agencies are currently initiating programs at the community level in a number of Pacific countries. Group certification can be used to certify a number of small enterprises that independently would not have the expertise or finance to meet the costs of certification (AusAID 2006).

Certification schemes, particularly pertaining to sustainable production, environmental management and ethical business practices, are particularly valued in the European Union and have become a key element of supplier–buyer relationships among leading European perfume manufacturers.

This trend is of particular relevance to the future development of the Vanuatu sandalwood industry. An interesting case study in the sandalwood industry is the Songman Circle of Wisdom Certification Protocol.

This case study can provide a lead to the Vanuatu sandalwood industry in its strategic and export market planning for a number of reasons:

- It is an international, 'whole of supply chain' business arrangement involving Indigenous producers, processors, exporters and leading global perfumeries.
- In essence, a premium is being paid for product sourced from an Indigenous community over and above the standard commodity price.
- The focus of the scheme is on sustainable production, quality integrity, traceability from harvest to final point of sale, and production of natural, unique end products.
- Involvement in the program is heavily and proudly promoted by the Australian processor, Mt Romance, and most importantly by Aveda and Givaudan. All of these companies see this protocol as a key element of their business model and preferred sourcing policy.
- There is due recognition of the key role of the Government of Western Australia in providing an appropriate regulatory framework to protect the resource.
- In the absence of available statistics, the volumes of product being marketed via this protocol are likely to be relatively small in global terms given the size of the available resource. Despite this, the program is effectively resourced and heavily promoted in the international marketplace, at little or no cost to the producers involved.

Product standards

Product standards are used to 'grade' and accurately describe a product, and are becoming increasingly important within the commercial forestry and essential oil industries. If a product has complied with a specified standard, it is deemed to meet specified minimum quality criteria. This can greatly enhance buyer confidence and facilitate export trade.

To be valued and effective, product standards must be measurable, achievable and verifiable. In the case of essential oils, such as sandalwood, verification is often carried out by accredited laboratories to enhance the independence and technical credibility of the

Case study: Songman Circle of Wisdom Certification Protocol

The growing demand for natural ingredients is often at odds with the ability of producers to supply raw materials in a sustainable way. This has been particularly evident in the international sandalwood industry.

In 2005, Australian sandalwood processor Mt Romance, together with global cosmetics company Aveda, joined Indigenous members of the Songman Circle of Wisdom to create an Indigenous plant certification protocol. In 2007, this agreement was extended to include one of the world's largest flavour and fragrance companies, Givaudan.

The protocol was designed to recognise the knowledge, rights and resources of Indigenous communities by building sustainable business partnerships between companies and communities, so as to share in the benefits of producing unique fragrance ingredients.

Under the program, Mt Romance assists Indigenous harvesters to obtain government licences to collect sandalwood. The wood collected by these groups is processed separately from the standard wood supply, and a royalty of $50 per kilogram is paid to Indigenous harvesters for the oil distilled from the wood. This fully traceable system is audited under the certification protocol.

Mt Romance, Aveda and Givaudan have also established a capital fund to assist Indigenous communities finance their involvement in the system. Funds can be advanced to Indigenous groups, allowing improvements such as more efficient and environmentally responsible harvesting. This money is then paid back interest free from the royalty paid to the Indigenous harvesters, allowing the funds to be advanced to another applicant.

Givaudan heavily promotes the program on its website, in company reports and in the media. Givaudan states that it has a responsibility to ensure that the natural resources it uses are sustainable so that it can continue to innovate, while also helping local communities. This philosophy is summarised on its website as follows:

> Enriching the palette of our perfumers with new and exclusive naturals, whilst allowing us to take the lead in implementing sustainable development and fair trade practices in our industry … We have a responsibility to ensure that the natural resources currently used are sustainable. At the same time it is in our interests to secure resources that will enable us to create unique fragrances, as whoever holds the broadest palette of natural ingredients has an advantage in creating the next masterpiece perfume. (www.givaudan.com)

process, for both processor and buyer alike. The most widely recognised product standard for sandalwood oil is ISO 3518:2002. Pertaining to *S. album* only, this international standard produced by the International Organization for Standardization (ISO) specifies certain characteristics in the oil, and the measurements and tests to be used to help assess its quality.

ISO standards are developed according to the following principles:

- *Industry consensus*: The views of all interest groups are taken into account, including manufacturers, vendors, users, consumer groups, testing laboratories, governments, engineering professions and research organisations.
- *Voluntary participation*: International standardisation is market driven and therefore based on voluntary involvement of all interest groups in the marketplace.

There are three phases in the ISO standards development process:

1. The need for a standard is usually expressed by an industry sector, which communicates this need to a national member body. The latter proposes the new work item to ISO as a whole. Once the need for an international standard has been recognised and formally agreed, the first phase involves defining the technical scope of the future standard.
2. Once agreement has been reached on which technical aspects are to be covered, affected countries negotiate the detailed specifications within the standard. This is the second or consensus-building phase.
3. The final phase comprises the formal approval of the resulting draft, following which the agreed text is published as an ISO International Standard.

It is also possible to publish drafts at different stages in the standardisation process. This is currently being done with Australian sandalwood (*S. spicatum*), for which a standard is under development (ISO/FDIS 22769).

Most standards require periodic revision. ISO has established the general rule that all ISO standards should be reviewed at intervals of not more than 5 years. On occasion, it is necessary to revise a standard earlier. To date, ISO has produced over 16,000 International Standards, published in English and French (ISO 2009). No internationally recognised standard currently exists for Pacific sandalwoods such as *S. austrocaledonicum*. Many industry stakeholders interviewed suggested that development of an appropriate Vanuatu Product Standard is a high priority.

Position of Vanuatu sandalwood

Existing products and markets

Current export markets for Pacific sandalwood are predominantly in Asia—in particular, China, Taiwan, Singapore, Korea and Japan, none of which have natural resources of sandalwood themselves. India, while a major producer, is also a major importer due to supply shortfalls in its domestic market (Thomson 2006).

The Government of Vanuatu has exerted a level of control on sandalwood harvesting and marketing. At present, there are only two licences to buy sandalwood issued to Vanuatu processors, each with demonstrated capacity. These licences represent a maximum 80 tonnes of sandalwood per year combined. This limit represents the current estimated annual sustainable harvest from the native resource as estimated by the VDoF.

Market demand and prices for low-value sandalwood products are said to be limited due to the availability of synthetics and substitutes. Opportunities for commercial sapwood production in Vanuatu are also said to be constrained or unviable due to internal and external transportation costs.

Future value of the Vanuatu sandalwood industry

Preliminary forward estimates provided by different stakeholders in the industry as to the future value of plantation sandalwood from Australia range from A$20,000 to A$41,000 per tonne for Indian sandalwood (*S. album*) and A$3,000 to A$16,500 per tonne for Australian sandalwood (*S. spicatum*) (AAG 2006). This variance in the estimates of future market returns for sandalwood shows that all such data should be treated with extreme caution.

Vanuatu sandalwood (*S. austrocaledonicum*) is rated in quality somewhere between Indian and Australian sandalwood, primarily based on its percentage oil yields and quality. Therefore, assuming a scale based on a conservatively low market return for Vanuatu sandalwood (*S. austrocaledonicum*) of A$10,000 per tonne and a conservative top market value of A$30,000 per tonne, it is possible to speculate on the broad scope of the future value of the Vanuatu sandalwood industry (Figure 23). As other sandalwood species have limited wild resources available and limited plantings for commercial production, such price trends may be expected to continue into the future.

Niche marketing

Declining global stocks of natural sandalwood, coupled with rising market prices, have led to an increase in the establishment of commercial plantations, particularly in Australia. Increases in commercial plantings are likely to lead to increases in global supplies; it is therefore important for Vanuatu to differentiate its sandalwood product from international competitors.

Opportunities for Pacific island sandalwood, including Vanuatu sandalwood, are likely to involve niche marketing, focusing on unique cultural dimensions and oil profiles (Thomson 2008). The Pacific Economic Survey (2009) reported that niche marketing can provide valuable opportunities for Pacific island countries, especially commodity exporters. The report found that product differentiation through branding, certification and value adding offered potential for improved returns (AusAID 2009). Developing certification programs can be expensive and problematic where demonstrating legal supply is difficult, such as in Vanuatu. Certification schemes may therefore need to be based on simple methods for identifying and registering plantings at the time of planting. These certificates may then be used to demonstrate to the market that the product is sourced from sustainable agroforestry.

One issue that the Vanuatu sandalwood industry must consider is the potential niche market advantage of differentiating product from *S. austrocaledonicum* from the Indian and Australian bulk product—and the potential market disadvantage of producing Indian sandalwood and hybrids in Vanuatu, thereby negating the opportunity for definitive species differentiation.

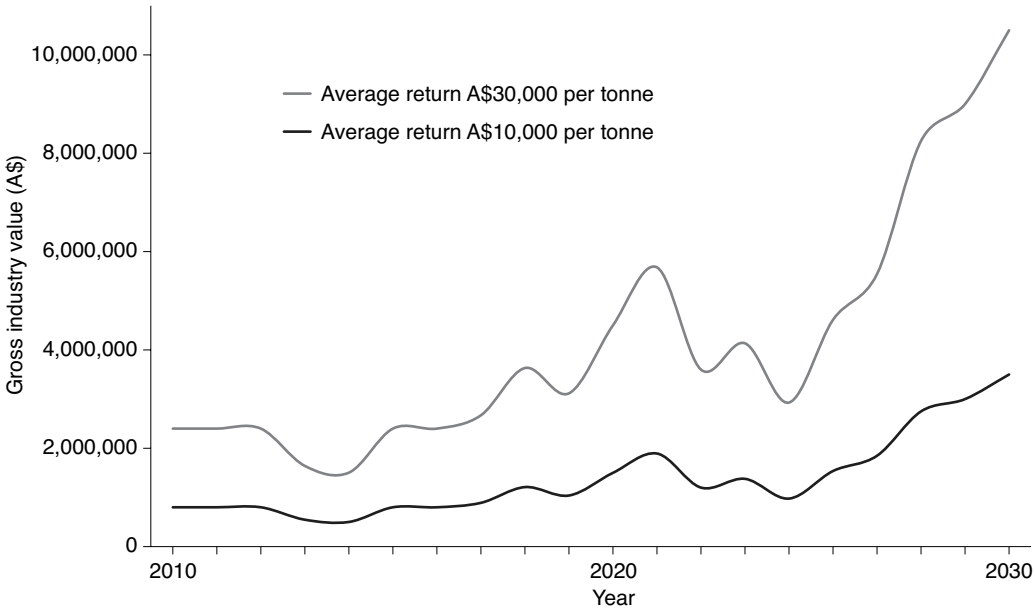

Figure 23. Possible range in the gross value of the Vanuatu sandalwood industry

Importantly, for the Vanuatu sandalwood industry to develop a sustainable niche market, it will need to provide consistent volumes of product over time.

Strengths and weaknesses of the Vanuatu sandalwood industry

Consideration has been given to industry weaknesses and threats (Box 2) versus strengths and opportunities (Box 3). This assessment, coupled with the proposed future production and market scenarios, provides a guide to industry options for future marketing strategies.

Optimism for the future viability of the industry

Sandalwood has three important factors favouring its commercial cultivation on Pacific islands:

- It is a native tree that is well suited to the growing environment.
- Its heartwood has a very high value.
- Its heartwood and associated products are non-perishable, which simplifies shipping and storage requirements.

The marketing of initially small volumes of plantation-derived product should fit within current supply chains for wild-harvested product. Markets for the increasing volumes of plantation sandalwood can be sought gradually through existing contacts and/or larger volume buyers.

While the growth of the sandalwood export industry in Vanuatu is likely to decline over the short term, there is an optimistic outlook for medium- to long-term prospects for the industry as a niche market producer. The basis for this optimism is:

- the current and projected high value of the commodity in world markets
- the high level of sandalwood planting that is currently being undertaken
- efforts to facilitate knowledge transfer and labour sharing
- industry growth from 2020 onwards once plantation stocks begin to mature.

As evidence of industry optimism, the increase in the level of planting by both smallholders and investment schemes throughout Vanuatu has led to a 1000% increase in the price of sandalwood seed, from 500 vt/kg in 2004 to 5,000 vt/kg in 2007 (Gillieson et al. 2008).

The VDoF has also been actively working towards all objectives outlined in the Sandalwood Policy (2002). The objectives of the policy are to:

- increase sandalwood stock through replanting
- facilitate sandalwood industries to engage fully in processing the wood locally

Box 2. Industry weaknesses and threats

- Large volumes of plantation sandalwood from Australia will likely enter the market from 2014 onwards.
- The impact of this on world sandalwood prices cannot be determined with certainty. Consequently, the Vanuatu industry must undertake strategic market planning and ongoing market monitoring and competitor analysis.
- No Vanuatu sandalwood industry peak body or strategic plan currently exists.
- The declining natural resource is reducing the size of the Vanuatu sandalwood industry, which will reduce Vanuatu's market presence in the short to medium term until an expected upturn in 2020 as more substantial volumes of plantation sandalwood come on line.
- There are likely to be regulatory and technical challenges associated with the 'merging' of native and plantation systems.
- The size and value of the current and projected resource in Vanuatu limit production and marketing options relative to high-volume producers.
- Introduction of other sandalwood species potentially threatens the genetic purity of the Vanuatu resource and limits the opportunity for differentiation in the market relative to higher volume Indian and Australian species.
- Vanuatu's very small size means limited economies of scale in purchasing, processing, distribution and marketing.
- Vanuatu has high internal transport costs and geographical isolation from large markets.
- Unique economic and social challenges exist at the interface between the 'traditional economy' and the 'modern economy' (Bazeley and Mullen 2006).
- Natural disasters such as cyclones can cause significant production disruptions.
- No industry grade standards or certification protocols have been determined or implemented.
- There has been limited investment in market research and development to date.
- Vanuatu's small domestic population limits domestic marketing opportunities relative to Australia.
- Land ownership constraints can inhibit investor confidence.

- conduct research and provide information on sandalwood, to identify and promote the best sandalwood variety
- conduct an inventory survey to establish information on sandalwood stock, to identify and promote appropriate management measures
- establish a proper control measure for better management of sandalwood harvesting and trading (Gillieson et al. 2008).

Santalum austrocaledonicum has some populations containing trees with a heartwood oil of a quality that meets the international standard for *S. album*. While this identified genetic material is of significant importance to the sandalwood industry in Vanuatu, its commercial value will only be realised if a planted sandalwood industry can be established. A priority in Vanuatu is therefore to stimulate and promote rapid development of such initiatives.

Research has identified sandalwood selections with high-quality heartwood oil (Page et al. 2010) that are now being used to develop superior seed stock. Such research, combined with the extension work carried out by the VDoF and its research partners, has contributed to the stimulation of interest in planting by both smallholders and investors. The department has also been encouraging industry to adopt processing technologies to increase the quality of Vanuatu sandalwood products and their export value (Gillieson et al. 2008).

Options for future market development

Tourism has become an increasingly significant industry in Vanuatu, representing approximately 20–25% of gross domestic product since 2005 (TRIP 2008; AusAID 2009). The Vanuatu Statistics Office reported that 196,795 visitors (including air and cruise ship visitors) entered Vanuatu in 2008. This was up from 99,328 visitors in 2004 (VNSO 2008). Expenditure by tourists in the category of 'local shopping' alone (excluding purchases of food, drinks and duty-free shopping) was estimated at 2.181 billion vatu (approximately A$24.5 million) in 2007 (TRIP 2008).

Box 3. Industry strengths and opportunities

- Industry priorities have been defined within a sandalwood policy.
- Vanuatu sandalwood is currently perceived as being of higher quality than *S. spicatum*.
- A unique natural and cultural environment and vibrant tourism industry in Vanuatu may offer domestic marketing opportunities (e.g. agritourism and 'suitcase export' of locally made goods).
- The exotic images associated with Vanuatu, if coupled with certified sustainable production practices, could be developed as the basis of niche marketing strategies in high-value markets.
- Linkages are evident among many key stakeholders (government and private sector). The consideration of issues of common concern presents an opportunity for the establishment of an industry peak body.
- Pre-existing commercial-sector investment and processing infrastructure exist.
- An available land resource exists that is conductive to sustainable production.
- Research and development programs are being undertaken to improve product quality and promote industry investment and growth (Page et al. 2010).
- Local people have experience in commercial production and processing techniques.
- Production of locally made products using sandalwood could be viable, sold via existing retail outlets or within an agritourism, Mt Romance type facility in or near Port Vila.
- The sandalwood industry can 'partner' with other Vanuatu industries (e.g. tourism) in activities such as the development of promotional programs and branding.

Given the vibrant and expanding tourism industry in Vanuatu, opportunities may exist for marketing Vanuatu sandalwood products domestically, focusing on producing value-added products for sale within existing retail outlets accessed by tourists, or as part of an agritourism facility, such as described in the Mt Romance case study. This is particularly relevant given the recent increases in the tourism sector in Vanuatu and the demand for cultural attractions that are unique to Vanuatu.

A number of activities, including niche market positioning, improved cooperation among industry participants, the establishment of a peak industry body and the development of product standards, could improve the future growth and viability of the Vanuatu sandalwood industry (Table 8). These market

Case study: Mt Romance

Beginning as a family business selling cosmetic products at local markets, Mt Romance is now the world's leading supplier of Australian sandalwood oil (*Santalum spicatum*). Mt Romance promotes itself as:

> Working with the aromatic Australian Sandalwood tree to produce an essential oil renowned for its sustainability, aroma and therapeutic properties … through fusion of Indigenous wisdom with scientific and commercial capabilities, Mt Romance has helped establish Australian Sandalwood oil as a unique ingredient in the global fragrance and cosmetic industries.

Mt Romance is an internationally known supplier in global markets. Its range of retail products includes soaps, cosmetics, toiletries, candles and perfumes sold online or direct from *The Sandalwood Factory* in Albany, about 5 hours south of Perth, Western Australia.

This regional tourist attraction offers visitors the opportunity for tours, shopping, dining and relaxation.

Source: www.mtromance.com.au

development strategies are based on the perceived strengths and weaknesses of the Vanuatu sandalwood industry discussed above (Box 2) (relative to international competitors). Consideration of case studies presented in this report, where industry development and niche marketing strategies have been used with success within the broader sandalwood industry, may be used as a guide for similar developments in Vanuatu.

Table 8. Possible market positioning strategies for the Vanuatu sandalwood industry

Strategy	Description
Niche market positioning—marketing supply chains	A niche market focus for Vanuatu sandalwood could be establishing supply chains that focus on one or two appropriately sized, premium niche markets in which the selected buyer places a significant commercial value on developing long-term relationships with suppliers—particularly suppliers who are independently certified as practising sustainable, ethical production systems—while also producing high-quality products in accordance with predetermined quality standards. Example: Mt Romance–Aveda–Givaudan marketing supply chain.
Peak industry body—strategic planning	A peak industry body (formal or informal) would help move the industry forward in a planned, coordinated manner, therefore increasing the potential for future success. Strategic market planning will also be crucial if the industry is to reach its full potential. Timing is critical here, with declining natural resources and a move towards a more structured, plantation-type industry over coming years likely to change aspects of production, processing and marketing systems. While recognising the commercial sensibilities and differing views that exist, every effort should be made to bring the industry together to develop a cohesive industry development plan. This plan should focus on areas of critical importance and common concern—for example, reaching consensus on an overall market focus, and research and development priorities. Example: WA Sandalwood Industry Development Plan 2008–2020.
Product standards—certification schemes	Certification schemes and product standards are becoming critical elements of supplier–buyer relationships, particularly in high-value European sandalwood markets. Development of certification programs and product standards should therefore be a priority for the Vanuatu sandalwood industry and could be championed and coordinated by a peak industry body. Examples: ISO/FDIS 22769 (*S. spicatum* draft standard) and Songman Circle of Wisdom Certification Protocol.

Policy issues for the development of the sandalwood industry in Vanuatu

Before the late 1990s, the sandalwood industry in Vanuatu was largely unregulated, with little control over volumes harvested or prices paid to resource owners (Gillieson et al. 2008). The industry was characterised by periods of high extraction and exploitation of resource owners. The introduction of the Management and Control of Sandalwood Trade and Exports Order (No. 3 of 1997) enabled greater regulation through licensing of sandalwood merchants and collection of government royalties. This initiative brought relative stability to the industry and improved prices for resource owners. The Sandalwood Policy (2002) included requirements for licensees to secure export permits before any sandalwood purchased under the licence can be exported. The policy restricted the export of unprocessed logs and only allowed a licensee to export oil, powder, spent biomass, and carving wood or carvings. From 2001, the industry has had two licensed buyers, each with an annual 40 tonne licence. In 2007–08, an additional 10 tonne annual licence restricted to Tanna was in operation, but the enterprise has since ceased.

Sandalwood is the only species to be named in the objectives of the National Forest Policy (1997), which recognises the importance of its value to the local and national economy. Achieving the objective to 'improve the management of sandalwood and encourage the development of sandalwood industries' in this policy is supported by the regulation of cutting seasons and encouragement of local processing.

Some policies have been introduced in the past 10 years to improve the management of sandalwood and promote the growth of the industry in Vanuatu. These policies relate largely to the wild harvest industry in terms of setting annual harvest quotas and managing purchase licences. The industry has also benefited from the active promotion of planting of sandalwood by both government and private organisations. Attracting further investment into this planted sandalwood sector, however, requires new policies relating to security of tenure over plantations and rights of producers to market their own sandalwood.

Land tenure and sandalwood plantings

Land in Vanuatu is owned collectively or individually, through custom, giving owners the right to develop and cultivate their land. Policy development regarding the planting of sandalwood will need to recognise custom land-ownership rights. Any change in policy should not be retrospective and should only apply to those plantings established after any new legislation or policy initiative. With high population growth (2.8%) (VNSO 2009), land available for planted forestry in some highly populated areas (i.e. Tanna and Paama) is decreasing as the number of users increase. Increasing planted forestry in areas of high population density may negatively impact on food production in these areas, and, although sandalwood can provide additional income, food security is of higher priority in Vanuatu. The high value and relatively small size of sandalwood trees, however, puts it at a distinct advantage to other forestry species, since it can be economically viable to plant small numbers of trees within boundary plantings, as ornamental trees in the village and as enrichment plantings in areas marginal for agriculture.

No legal framework currently exists to secure freehold land in Vanuatu; only leasehold land with 50–75-year periods is available. Investors wanting to plant sandalwood would need to buy an existing agricultural lease or negotiate a suitable lease with a custom owner. The *Forestry Rights Registration and Timber Harvest Guarantee Act 2000* allows provision for registering a forestry right (Part 2) or the accreditation of a timber plantation (Part 3, Division 3). Both investment and joint-venture sandalwood plantings undertaken individually or in partnership with a custom landowner can be registered as a forestry right

or recognised through an accreditation of a timber plantation. Both these forms of registration protect the rights of producers and investors to harvest their crop at maturity.

A forestry right requires the applicant to provide a land title, surveyed and registered by the Vanuatu Lands Department and therefore a land tenure recognised under the *Land Leases Act 1988*. A forestry right enables the holder to 'establish, maintain, and harvest or maintain and harvest a crop of trees on the land'. This may therefore include both plantation and natural timber stands.

An alternative to the forestry right is an accreditation of a timber plantation with the Vanuatu Department of Forestry (VDoF). The accreditation requires identification of the area(s) of land comprising the current or proposed timber plantation by way of a map, survey plan or other suitable means. This must be accompanied by details and supporting evidence relating to the current or proposed timber plantation. The simple process for accreditation secures the rights of smallholders and investors to harvest their planting(s) at the end of the rotation.

A sandalwood plantation can be accredited by the VDoF on either registered leasehold land or custom title. In cases where a land lease is not registered, ownership of that land can be challenged by others. The establishment of joint-venture/collaborative plantings on custom lands may make the land more attractive for potential challengers or claimants of that land. Therefore, public announcements of joint-ventures on customary title land should be made, and allow the land to be challenged before commencement of the joint-venture. This should help limit the likelihood of challenges during the course of the investment. Provided that public announcements are made before planting, contracts between investor and landowner are in place, and the planting is accredited by the VDoF, any successful land tenure challenges during the sandalwood rotation are not likely to affect the original investment contract(s).

The most secure option for investing in sandalwood plantings in Vanuatu would be to secure a leasehold property. Structuring an agricultural investment in this way, however, is often viewed unfavourably by the government and community for its alienation of indigenous ni-Vanuatu landowners. The option of accrediting a plantation is available on land with registered leasehold or customary title, and ensures security of ownership of the plantation regardless of land ownership.

Both a forestry right and accreditation of timber plantation are exempt from the regulations within the *Forestry Act 2001*, which requires the issuing of a sandalwood licence, and the *Physical Planning Act 1988*. A general consensus within the industry is that holders of either a forestry right or an accreditation of a timber plantation should also be exempt from the *Vanuatu Commodities Marketing Board (VCMB) Act* (*CAP 133*) or any similar successive legislation. Under this Act, the VCMB has the authority to 'prescribe' any agricultural product and exert monopolistic control over its import and export. If sandalwood was 'prescribed' by the VCMB, then 'no person other than the Board, its agents or persons authorised in writing by the Board shall export or import (it) out of or into Vanuatu' (Republic of Vanuatu 2006). The potential loss of control in marketing planted sandalwood, however small that potential may be, is counterproductive to attracting investment into sandalwood plantations in Vanuatu.

Marketing of products from sandalwood plantings

Although the *Forestry Rights Registration and Timber Harvest Guarantee Act 2000* is important to secure the rights of plantation owners to harvest their trees, it does not encompass their rights for marketing. The marketing of plantation sandalwood would therefore be subject to the conditions outlined in the Forestry Regulations (Management and Control of Sandalwood Trade and Exports). These regulations restrict the purchasing, trading, processing and exporting of sandalwood, sandalwood oil or any sandalwood product to those with a sandalwood licence. Therefore, any owner of a sandalwood plantation would need to secure a sandalwood licence before being able to export any product. The licensee would be subject to the restrictions of harvesting within the specified sandalwood harvesting season, typically during the months of May to September of each year. Such restrictions may not be an issue given that the harvesting season is during the driest months and is also likely to be the best time to harvest planted sandalwood. To guarantee control over the end market of trees planted today, sandalwood planters need to secure a purchasing licence and hold that for the entire rotation. As the *Forestry Act 2001* only allows a licence to be granted for a maximum of 10 years, planters need to obtain a minimum of two licences before any trees could be harvested.

The current marketing duopoly operating in Vanuatu was established to limit the volumes of sandalwood harvested from the small wild resource, while maintaining competition to ensure that resource owners gain a fair price. While this industry structure is highly appropriate for the current wild-harvest industry, it does not encourage larger investments for establishing planted sandalwood resources. The transition from the current system to an open market for planted sandalwood, however, needs to be managed carefully, since it is difficult to distinguish wild from cultivated trees. The current registration system for planted sandalwood administered by the VDoF may provide the means to allow two distinct systems of marketing to operate simultaneously. For example, individuals or organisations that accredit their plantations at or near establishment may be permitted to market their product on the international marketplace, while those without accreditation may need to market through the regulations set out for wild-harvested sandalwood.

Growing other sandalwood species

The sandalwood industry in Vanuatu is currently based on harvesting the only native species, *S. austrocaledonicum*. Although seed of *S. album* has been planted on Efate with a view to improving Vanuatu's place in the international marketplace, further expansion of plantings of introduced sandalwood species is contentious, particularly with respect to (a) the potential impact on the marketing of a Vanuatu 'branded' product and (b) the high likelihood of other species hybridising with *S. austrocaledonicum*. The decision to allow the introduction of *S. album* into Vanuatu was undertaken without genuine industry and public consultation. Given the implications of this decision for both marketing and the biology of *S. austrocaledonicum*, it is recommended that this issue is given greater attention by the Government of Vanuatu and that a formal review is established to determine and document the policy position on the introduction of exotic sandalwood.

Conclusions and recommendations

An estimated 1,800 smallholders have begun establishing small (<1 ha) sandalwood plantings, and there is considerable scope for more smallholders. Collectively, the smallholders of Vanuatu have a unique opportunity to develop a commercially viable agroforestry industry by combining the production of sandalwood with their existing garden areas. The use of sandalwood under these agroforestry systems is appropriate since they incorporate a heavily exploited indigenous tree producing a high-value, low-volume and non-perishable product with export potential. The domestication activities currently occurring can ensure that in future the industry will use a high-quality genetic resource that will be competitive in the international marketplace. Availability of the improved genetic materials across all islands with a suitable climate will help make this lucrative industry more equitable.

Benefits of growing sandalwood

The commercial production of sandalwood within smallholder agroforestry provides an asset, which could be used as collateral to secure microfinance and improve economic development. Sandalwood production is often referred to as the only long-term saving option for smallholders that can improve financial security and ultimately their livelihoods. On a national scale, the production of sandalwood may help to alleviate the harvesting pressures of contracting wild stands while providing a source of foreign exchange and government revenue.

Advantages of sandalwood production over other agricultural crops in Vanuatu are that buyers typically pay for the product at source, and meet all the costs of transport and processing after desapping. The production of sandalwood fits easily within the current practices of subsistence agriculture, where sandalwood is planted in a newly established mixed cropping garden and benefits from the high soil fertility and maintenance associated with that garden, and effectively reaches a 'self-maintaining' size as the garden is abandoned. This study also demonstrated that the production of sandalwood in smallholdings is highly profitable, with a net present value of approximately US$22,000, which is 13.5 times that for current swidden agricultural practices in Vanuatu.

Constraints on the industry

The current marketing duopoly operating in Vanuatu does not discourage smallholders to invest their time in establishing sandalwood woodlots; however, it is likely to limit larger scale planting investments in the country and thus the opportunity for the government and domestic economy to benefit from new employment opportunities and increased revenues from the export of product generated from such investments. This policy area requires further review to ensure that a balance between the protection of natural populations and open competition can be met.

A major constraint to the development of the industry lies in the limited availability of planter bags, especially for smallholders. Planter bags are often not available in the major centres of Luganville and Port Vila, since they are often pre-sold before importation to relatively wealthy urban wage earners, who have planting interests in their home village. Although this interest is encouraging, further competition in the planter bag market is required to ensure that people of all demographics have the opportunity to participate in this potentially lucrative agroforestry industry.

Another major constraint is the current availability of seed, particularly for those residing north of the island of Efate. Although many smallholders have a keen interest planting sandalwood, the limited availability of seed excludes them from participation. Opportunity exists to scale up the existing improved clonal seed orchard in Port Vila and make the improved seed available to the outer islands. This strategy will not only meet the growing demand for seed, but also ensure that new plantings and future supply consist of trees producing high-quality oil.

Promotion and extension

Ongoing extension activities are required to ensure that appropriate establishment and management techniques are implemented to maximise the economic value of sandalwood plantings. Development of awareness programs for nursery, planting, silviculture, pest management and pruning, particularly for the islands and areas without existing plantings, would optimise their productivity and ultimate contribution to national export earnings.

This study synthesised information and the experiences of local sandalwood planters in Vanuatu and used them as the basis of a silvicultural manual available for smallholders. This extension information provides the industry with the opportunity to advance its development through improved productivity, reduced rotations and higher quality products. With the high interest in establishing sandalwood woodlots across the country, sandalwood will be established in areas with local environments different from those of its natural range. This will present challenges for growers to adapt techniques to these new environments. This will require further evaluation of productivity and production issues in these environments and generalised strategies for meeting these challenges.

Given the presence of televisions and DVD players in most villages in Vanuatu, the development of video extension materials such as DVDs would be a very cost-effective method for connecting with farmers in areas beyond the reach of existing extension officers and programs.

Extension programs could comprise (a) workshops in areas with suitable bioclimatic conditions for sandalwood production, (b) publication and dissemination of the extension document developed as part of this project, (c) development of video extension material in the form of a DVD, (d) further collaboration with agricultural field officers during extension activities, as they have greatest contact with isolated rural areas, (e) use of national radio to hold regular discussion forums aimed at general awareness and dealing with specific smallholder issues through a 'talkback radio' format, (f) capacity building and extension workshops with Vanwod's Microfinance, since it has an extensive network of farmers and a fledgling sandalwood planting program, and (g) development of close links with any future peak industry body.

Outlook

The Vanuatu sandalwood industry is at a very exciting position, where for the first time in its recorded history the resource is rapidly expanding. Recent planting activity over the past 10–15 years has resulted in the establishment of between 420 and 700 ha of combined smallholder and commercial sandalwood plantings. With such independent planting activity continuing and the potential establishment of 230 ha of plantings under one microfinance project, the future economic impact is likely to be extensive, reaching many isolated communities. From the conservative estimates of this study, the national annual sandalwood yield in 2030 will be at least four times the current 80 tonne quota. Such an increase will have significant benefits to the local cash economy and ultimately improve ni-Vanuatu livelihoods.

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