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Can traditional forest management protect and conserve ironwood (ulin) stands? An option and approach in East Kalimantan

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1 Introduction and literature review on ulin: Borneo ironwood (*Eusideroxylon zwageri* Teijsm. and Binn.)

1.1. Introduction

This research was developed within the framework of the Tropenbos Kalimantan Programme and as part of the project 'Sustainable Management of the Tropical Rain Forest in Kalimantan: Silviculture Development and Genetic Conservation of *Eusideroxylon zwageri* Teijsm. and Binn.' My studies also form part of the Ironwood Co-management Project, a collaborative research project of Indonesia's Ministry of Forestry (hereafter MoF), Tropenbos Kalimantan Programme in Kalimantan, Indonesia and the Forest Research Institute of Kalimantan in Samarinda.¹ The project was initiated in 2004 and was based on a mutual interest in a specific tree, the Borneo ironwood (hereafter, ironwood) (*Eusideroxylon zwageri* Teijsm. and Binn.). The trade name, the local and popular name for ironwood is 'ulin' (Indonesia) although it also has many vernacular names (see Appendix 1). This project studies co-management approaches, in order to demonstrate their applicability as a sustainable, equitable and efficient management strategy, and to develop models for use and adoption by governments, forest communities, non-governmental organisations (NGOs) and others. The overall purpose of the Ironwood Co-management Research Project is to determine the prospects for successful implementation of ironwood co-management strategies.

My research was funded by the Tropenbos Kalimantan Programme, together with the Forest Research Institute of Kalimantan, the NGO PEMA (*Persatuan Masyarakat Adat*) Paser and Mulawarman University. My research covers the natural distribution and tree diversity of ironwood in association with the variability of ironwood. It also covers socio-economic aspects, such as the local traditional forest management system,

¹ Since June 2006, the name of the institution has been known the Dipterocarps Research Centre (Di-ReC). Its main task is to generate science and technologies for the conservation, rehabilitation and sustainable management and it concentrates on research of Dipterocarpaceae tree species.

cultivation and conservation efforts by indigenous people. In addition, it examines the current trade of ironwood products in East Kalimantan. This research forms part of wider efforts to study traditional forest management, conservation, including those issues and problems encountered by local villagers. The overall objective of my research is to study and analyse the community-level use of ironwood as a part of a strategy for sustainable forest resource management, with a view to developing future strategies and models.

Rationale of the study

The logging of tropical timber in Southeast Asia is a major environmental problem. The disappearance of tropical forests and other natural habitats for both animal and plant species is occurring at such a rapid rate that it has been suggested that the sixth phase of mass extinction of species is currently taking place on the planet. Tropical forests are home to some 90 per cent of the world's terrestrial species (IUCN 2007). Unlike other forest types, tropical rain-forests also have a wealth of rare plants and animal species. Many species found in tropical rainforests are included in the IUCN's Global Red List (IUCN 2010), which records those plants or animals with small or declining populations that are only found in one or very few locations. Many of these plant and animal species are endemic and inevitably, they become candidates for the IUCN Global Red List, when their habitat is disturbed or destroyed. A species is said to be endemic when it is found naturally in a single geographical area and nowhere else.

Covering 1.3 per cent of the earth's landmass, Indonesia is home to 10 per cent of the world's rainforests and 40 per cent of Asia's rainforests. This nation has been blessed with the second most ecologically diverse rainforests in the world and some 19 different forest types have been identified and contain an overwhelming amount of biological diversity (biodiversity) (Barber 1998). Tropical forests in Indonesia are extremely rich in tree species with an estimated 10,000 species in total. Approximately 5 per cent of these are currently recorded as globally threatened (IUCN 2010).

Indonesia's productive forests with high levels of biodiversity are in a critical state. 2010 UN Food and Agriculture Organization report indicates that deforestation rates in Indonesia have declined drastically from 7336 mi² to 1931 mi² per year since 2000. However, by including plantations in reforestation rate calculations, these numbers obscure the reality that natural forest loss has continued at an alarming pace (FAO 2010). Logging has had a particular heavy impact on lowland forests, in Kalimantan and Sumatra.

Forest resources are widely used throughout the world for a host of reasons and trees are the fundamental components of many ecosystems, human economies and also an intrinsic part of almost the entire world's forest ecosystems. These ecosystems provide services of important value to people, including climate control, water catchments,

medicine, food and timber. Tropical tree species are the most important economic timbers of Southeast Asia. Trees may be specifically exploited, due to the particular properties of their timber, fruit or sap. It is important to note, however, that an internationally important timber species may also be important locally due to its medicinal and cultural value. In countries like Indonesia, approximately 50 per cent of construction material for local communities comes from local timber consumption. This can result in heavy pressure for local extraction caused by cumulative local and international demand. When international demand leads to the decline of a commercial timber species in its natural habitat, it not only results in impoverishment of the environment, but the poorest of the poor also suffer directly from the loss.

Forests are central to the economic livelihoods of the societies surrounding them. Biodiversity is important for human livelihoods and the survival of humanity. It is my impression, supported by Nanang and Inoue (2000), that the government in Indonesia, often neglects the indigenous people or forest villagers living in and close to the forests in the outer islands (like the Dayak of Kalimantan) in their forest management approach. This neglect has affects the way in which the government pursues 'economic development' through the exploitation of forests and forest by products whilst ignoring the long term inhabitants of those areas. The forests, far from empty, are home to indigenous cultures and their great knowledge of the forest ecosystem, endangered flora and fauna, valuable medicinal plants, and hardwoods that hold an immeasurable wealth, which if destroyed can never be restored (Crevello 2003). In short, there is now an urgent need in Indonesia to conserve and manage forested areas and protect the people who live in them and depend on these resources for their livelihood. Degradation of natural resources, reduced access to markets and a lack of political power to reverse these processes are a severe threat to people's livelihoods. Increasing competition and conflict over limited resources exerts further stress on forest management systems.

Borneo is home to at least 3,000 species of trees, including 267 species of dipterocarp (the most important commercial timber trees in Southeast Asia). Of these, 58 per cent are endemic to the island (WWF 2005). Some of the trees are of great economic and local importance as a source of timber, medicinal products and food. A large number of commercial tree species are now considered to be threatened with extinction and are on the IUCN Global Red List (IUCN 2010). Little is known about the botanical and conservation status of the majority of Indonesian tree species and many species will be lost before their ecological and economic values are fully understood. With over 1,000 tree species threatened with extinction as a result of deforestation, the sustainable management of forests is a top priority for the Indonesian government. Kalimantan has over 250 endemic tree species many of which are under threat from direct extraction and from fires. The forests of East Kalimantan contain more than 800 tree species listed as threatened on the Global Red List of the International Union for the Conservation of Nature (IUCN), as well as several endangered animal species such as orangutans, proboscis monkeys, sun bears and gibbons ([The Nature Conservancy](#)

2006). In addition, the populations of at least 14 forest plant species have drastically been reduced and threatened by forest clearance during the past decade, ranging from ornamental species, such as *Rafflesia arnoldi* to important commercial timber species such as Borneo ironwood.

Across the globe, more than 100 species of trees and shrubs share the common name of 'ironwood'. They have earned this name as a result of their very hard, dense, and heavy wood. In Indonesia, there are many different tree species which are known by the name ironwood or *kayu besi*, including Borneo ironwood, Ceylon ironwood (*Mesua ferrea*), which belongs to the Garcinia family (Clusiaceae), and 'Merbau' (*Intsia spp*) in Papua.

My research focuses on a single tree species, Borneo ironwood, which has shown a dramatic decline in numbers in recent years. The ecological importance of ironwood has been well documented by tropical forest scientists.² Commercial opportunity and demand is the main driving force behind the destruction of ironwood stands in Kalimantan. While some measures are in place to reduce the extraction and marketing of ironwood, ironwood cutting has become a highly controversial issue and the subject of debate among producers, consumers, and environmentalists throughout Kalimantan and Indonesia.

There are many constraints on the effective management of ironwood. Indigenous people lack the authority, organisations and the incentive to restrict the use of state forest land. Local systems of management lack both the legal basis and economic incentives to stop this destruction and, moreover, have never been adapted to the constraints and opportunities of the modern market oriented economic system. Results of research on Borneo ironwood must be made available to decision makers and NGOs working with local communities on sustainable development and conservation issues.

In addition, data and information about the traditional forest management of ironwood from Kalimantan are limited, rarely explored and form only a small fraction of the extant studies. Indeed, most studies conducted on ironwood concentrate on silvicultural methods, the distribution of natural ironwood and conservation efforts relating to ironwood. It is vital to understand that in East Kalimantan the land use systems and cultural dynamics of the traditional Paser people, an indigenous group, are facing pressure due to Indonesia's rapid development and the decentralization of the forestry sector. To understand more about ironwood utilisation, we must examine how present ironwood utilisation has developed over long time-scales. To this end, my research also covers the historical aspects of ironwood utilisation, as well as its productive aspects, in order to discuss the sustainability of timber resources utilisation. In addition, my research examines a number of the vulnerable aspects of ironwood, such as its slow

2 Whitmore 1984; Whitten et al. 1987; Suselo 1987; Jacobs 1988; Sidiyasa 1995; MacKinnon et al. 1996; Sheil & van Heist 2000.

germination, its slow growth and its limited capacity to produce of seed trees. Indeed, it seems appropriate to suggest a more explicit approach to the joint management of ironwood. Moreover, collaborative management is an alternative approach to addressing the challenges of the conservation and sustainable use of ironwood.

Natural distribution and tree diversity in association with the variability of ironwood

Tropical forests often are referred to as one of the most species-diverse terrestrial ecosystems. Many researchers have argued that their immense biodiversity generates a variety of natural resources that helps to sustain the livelihoods of local communities (Kumar et al 2006; Murniati et al. 2008). Trees form the major structural and functional basis of tropical forest ecosystems and can serve as robust indicators of changes and stress factors at the landscape scale. Due to its bio-physical, biological and commercial characteristics, ironwood has great potential to become the basis for a sustainable use-and management system for tropical forests, applied within a framework of appropriate silvicultural practices. That said, in most cases, former and current use systems tend to promote the cutting of the best trees, regardless of forest regeneration and future growth, a practice that is frequently in conflict with sustainable exploitation.

The primary research question of my study on the natural distribution and tree diversity in association with the variability of ironwood at the research sites are:

1. What is the natural distribution of ironwood and tree diversity in association with the variability of ironwood at the research sites? (Chapter 3)
2. What is the role of ironwood in the forest ecosystem? (Chapter 3)
3. What is the impact of traditional management systems on natural ironwood stands at the research sites? (Chapter 3 and 4).

Traditional forest management and utilisation strategies for ironwood

Many researchers and NGO activists have argued that indigenous methods of managing and utilising forests are sustainable and hence must be promoted (Sponsel et al. 1996; Poffenberger 1990; Alcorn & Molnar 1996). This classification emphasises that indigenous forest management should not be considered as an isolated activity, but rather as forming either a utilitarian or a cultural component (Weidelt 1993) of local livelihood systems. It is general assumed that many of the indigenous cultures of Dayak communities possess a great diversity of ecological and ethno-botanical knowledge (Caniago & Siebert 1998; Alcorn & Antoinette 2000).

Within the Indonesian context, the issue of indigenous peoples has, for a long time, been denied by politicians (Nanang & Inoue 2000). A special development programme, designed and implemented by the Department of Social Affairs since the late 1970s, aims to return these people to what is labeled as the 'mainstream' of Indonesian economic and cultural life. This development frequently erodes people's traditional knowledge of their environment (Lindayati 2002). Efforts to develop local-based forest management have been developed in Indonesia since the eighties (Nanang & Inoue 2000; WRM 2002).

In 1980, Indonesia's forestry department implemented a policy requiring permits to harvest minor forest products. This policy sought to formalize and to protect the rights of forest-dependent communities to harvest and sell commercial forest products through the establishment of formal state-controlled co-operatives. This requirement had an impact on the conflicting tenure systems for the extraction of ironwood (Peluso 1992). This timber extraction in Kalimantan is an example of how state tenure policies can accelerate destruction of a common-property resource.

In Indonesia, 'social forestry' is an umbrella term for government participatory forest management programmes. According to Inoue (1999), even though there are several governmental social forestry programmes, only two of them the community forest programme and individual forest programme can be regarded as participatory forest management systems. Forest control privileges have been given to the private sector and to government supported parastatals such as Inhutani. Within the vibrant spirit of reformation in Indonesia (following the resignation of former President Suharto), there has been much discussion at local and national levels regarding the review and revision of the forest management system. Following the Suharto era, more attention has been given to ceding increased control of forest management to local people using their own traditional systems. Today, modern ways of life penetrate further and further into previously isolated communities. The potential usefulness of traditional environmental knowledge has been recognised by other branches of the state apparatus, but not in ways that concede much on the issue of rights.

In many cases indigenous forest management consists of practices for modifying the forests within the framework of an integrated system of resource utilisation; these practices augment crop cultivation and/or livestock management. It is also supported by Sorenson (in Schultze & Schone 1996) who has studied traditional Dipterocarp forest management and has found that subsistence exploitation can indeed be sustainable. Many researchers have argued that indigenous extractions of timber resources are generally for subsistence purposes and not for the external market. Small-scale low impact forestry, which is often practiced by indigenous groups, causes very little damage to the ecosystem (Colfer 1997; Lawrence & Moge 1996). In some cases, when indigenous groups fell trees, it may cause a minor amount of damage to the surrounding vegetation (Lawrence & Moge 1996). The gaps caused by small-scale tree felling by Dayak communities are not much larger than a natural tree gap (Schultze & Schone 1996). If timber is removed

from tribal land there is an effort to do as little damage as possible because the local communities realize that trees will need to be extracted in the future (Colfer 1997).

Hinterland villages in East Kalimantan claim *de facto* rights of access and withdrawal over fairly extensive areas of land and forest, through a set of rules and regulations called *wilayah adat* (traditional territory). Traditional forest management is a part of *wilayah adat* activities that lays down the basic ethics and codes of conduct for local people and it is an intrinsic part of the local culture. The rights of indigenous forest villages in East Kalimantan to convert or use particular forest territories and products, are conveyed in multiple sets of customary access rules called *adat*. Indigenous communities are often marginalised by large-scale development activities, initiated by the government or the private sector (Nanang & Inoue 2000). This is because most of their *adat* lands overlap with industrial timber estates and oil palm plantations, and the government has categorised these lands as grasslands or unproductive lands to be converted into productive uses. This has led to increasing calls for land reform and more sustainable resource-management options, such as involving indigenous communities in the land use decisions and allowing them to incorporate their own approaches to natural resource management into a system of community-based management.

My research explores how traditional forest management of ironwood and the sustainable use strategy of local communities can be adopted and developed in order to manage and protect the ironwood within traditional territories. As part of long and enduring local resource management systems, traditional forest management offers an important research opportunity. The availability of ironwood features prominently in ongoing treaty and land rights negotiations between local communities and central and provincial governments. Thus, despite all the changes in peoples' ways of life, the culture is still resilient enough to retain its focus on ironwood.

The research questions regarding traditional forest management and utilisation strategies for ironwood have been defined as follows:

1. What are the landscape and land use patterns related to ironwood conservation by indigenous people in the research sites (Chapter 4)
2. What is the impact of the traditional management systems on natural ironwood stands (Chapter 4)
3. What are the ecological knowledge and traditional techniques for sustainable use pattern strategies and the present use of ironwood by indigenous peoples (Chapter 4)
4. Which factors in the socioeconomic context affect stocks of ironwood and what constraints can be identified (Chapter 4)
5. What are the external factors influencing the traditional management of ironwood (Chapter 4)

Silvicultural knowledge and conservation efforts relating to ironwood

Forest management has been defined as the practical application of scientific, economic and social principles to the administration and working of any area used for forestry for specific objectives (Ford-Robertson & Winters 1983). Duerr et al. (1979) state that forest management should therefore be considered to involve not only silvicultural practices, but all conscious human activities directed at maintaining its production capacity. It can best be defined as the process of making and implementing decisions about the use and maintenance of forest resources and the organisation of related activities.

Tree scarcity is the outcome of both long-term and recent processes and events. In some places, pressures have been building up gradually and almost imperceptibly. Where pressures build little by little, people have sometimes had time and the opportunity to evolve and adapt management systems. In these cases signs of scarcity may have been present for decades, but adaptive strategies such as the protection of valued trees, the encouragement of volunteer seedlings and selective thinning may have prevented acute manifestations of deforestation from developing. In other cases, however, the loss of tree cover has tended to accelerate. In East Kalimantan, where considerable planting of ironwood by small-scale farmers has already taken place (Yusliansyah et al. 2004), measures are underway to assess the current genetic base of material planted by farmers.

The research questions in relation to the cultivation and conservation efforts of ironwood have been defined as follows:

1. What is the silvicultural effort regarding the cultivation of ironwood by indigenous peoples at research sites (Chapter 5)
2. What are the technological and social constraints faced by indigenous people in terms of their efforts on ironwood planting (Chapter 5)
3. What are the economic constraint and barriers faced by indigenous people in relation to their efforts on ironwood planting (Chapter 6)

The chain of production to consumption

Ironwood timber is very useful for many products made by industrial and local enterprises. Aside from its primary purpose, which is heavy construction, the wood is also popular for use as roof shingle (creating unique and colourful roofs) and for souvenirs such as statues and wooden ornaments. Recently in East Kalimantan, ironwood trees have been cut in order to fulfill the demands not only of local use, but also of modern processing. It is frequently used for foundation and frame-structure of local houses and large constructions such as bridges, quays and boats. Producers and consumers of ironwood timber can be found throughout Kalimantan. Indeed, local ironwood construction

material can be purchased at most building material stores throughout Kalimantan. To a lesser extent, ironwood is sometimes used for other purposes.

The majority of human settlements in Kalimantan are concentrated in areas along the riverside and coastlines. These settlements are supplied and supported by transportation highways and waterways and their development goes hand in hand with a demand for wooden ships, house boats and houses, which are made mainly from ironwood. Most of the lowland areas of Kalimantan and southwest Sulawesi are densely populated wetlands that experience frequent flooding. People living around the rivers build their houses on ironwood stilts, which keep them safe from high waters following heavy rains. These traditional houses, which stand on poles, are preferably constructed on strong and water resistant wood, for which the ironwood is well suited. Public facilities, such as the bridges, footpaths and alleyways that connecting people living alongside the river commonly use ironwood that is bought and share among residents. Houses with an ironwood structure are ubiquitous in Kalimantan and South Sulawesi. Local people also used the wood for making the body structure of boats that can be found along rivers in Kalimantan and some islands of the Spermonde Archipelago located off the west coast of South Sulawesi (Salam 2007). Because clear-cutting and rapid exploitation has led to a crash in wild stocks, ironwood has been declared a protected species and it is therefore illegal to harvest it outside of forest production areas. In reality, however, illegal cutting and trade in ironwood products continues.

The research questions relating to the production and consumption of ironwood products are:

1. What are the sources of ironwood raw material from different status forests (Chapter 6)
2. What is the diversity and size of ironwood business and trading in East Kalimantan province (Chapter 6)
3. Which specific socio-economic factors drive ironwood trading (Chapter 6)
4. What are the side-effects of the ironwood business and trade in terms of illegal cutting and what can we learn about current ironwood markets (Chapter 6)
5. What is the current status of Forest Law Enforcement (FLE) policies to curb illegal ironwood trading and cutting (Chapter 6)

As both forest ecosystem and biodiversity are under severe pressure from human use, climate change and other external impacts, the practical application of science becomes more eminent. For a better understanding of the current problems relating to ironwood, some theoretical background is required. In general, this chapter describes the situation of one of the most important hardwood tropical tree species. This theoretical framework describes the theory of threatened species management and conservation,

with special reference to Borneo ironwood. This species is both a cultural keystone species and a commercially valuable tropical hardwood species. The related traditional ecological knowledge and the market chain help us to understand the role of humans in their environment and the impact they have on the ecosystem. In this chapter, I will also briefly discuss some of the propositions for improved conservation and management that have been formulated in response to the recent situation of ironwood. The objective of this chapter is to make a link between conservation theory and practice, building on the recent status of ironwood.

In a study dedicated to assessing the impact of forest management practices in Kalimantan, it is useful to consider the history of ironwood exploitation and trade in the region. In the Indonesian colonial era the Dutch needed trees for building their ships while the Japanese needed them for raw materials and building their houses. When the Indonesian gained control of the government in 1945, they needed trees for developing the national economy (Obidzinski 2003). This chapter also provides a brief overview of the main historical periods of Indonesia, how ironwood procurement and trade changed, and conservation efforts during these periods in the research area (East Kalimantan). These periods are pre-colonial and colonial, the period after independence and the period under the new decentralization era. The last section of this chapter will discuss the lessons that can be drawn from this historical overview.

Of particular interest is how important ironwood exploitation and trade has been in the region, how the procurement and trade have been organised, and who has benefited from this trade. It can be argued that some of these past experiences can provide lessons for future development efforts. This chapter, therefore, will also highlight how local people have fared under increased exploitation of ironwood, since this began some eight centuries ago.

Although the case study presented in this chapter is from East Kalimantan, information is also included from the neighbouring regions of Sulawesi and peninsular Southeast Asia. Much historical information is available from the southern and northern parts of Borneo as well as South Sulawesi, because early ironwood exploitation and trade was most intensive there. In fact, a number of historical studies have been conducted on early ironwood exploitation and trade in Southeast Borneo (e.g. Burkill 1935; John 1974 in Knapen 2001; Potter 1988, 2005). As a result, the information included here is predominantly from sources from that region. A number of the conclusions drawn from this material, however, are generally valid for other regions.

This sub-chapter also provides a brief historical and policy background for my study. I will describe the causes of forest degradation and then provide a brief description of the various forest management systems and development programmes. This sub-chapter will also form a stepping-stone for a deeper analysis of the real situation of deforestation and depletion that relates to the rapid biological extinction of certain species.

1.2. Identifying Borneo ironwood in danger of extinction

The scientific name of Borneo ironwood is *Eusideroxylon zwageri* Teijsm. and Binn., synonymous with *Bihania borneensis* Meissner and *Eusideroxylon lauriflora* Auct. It belongs to the family of *Lauraceae*, tribus of *Cryptocaryae* and subtribus of *Eusideroxylineae* (Kostermans 1957). In 1949, De Wit described a new species in this genus, *Eusideroxylon melagangai* Sym, but Kostermans (1979) later moved it into the new genus *Potoxylon* (*Potoxylon melagangai*). Today, in Indonesia, this native tree species is found exclusively on the islands of Sumatera and Kalimantan. It is one of the heaviest, hardest and densest woods and is the most durable timber in Southeast Asia. Ironwood is known to humankind and has importance as a building material due to both its strong physical characteristic and the cultural myths that surround it. It is also very important to local communities in Kalimantan, who use its wood for many purposes and its fruits as a medicine against, among other things, swellings. Valued mainly for its strength and resistance, and lured by the anticipation of high prices and high demand, many cutters are attracted to ironwood exploitation and, as a result, the resource has suffered widespread destruction. With the recent increase in prices, ironwood trees throughout the Kalimantan region have experienced heavy exploitation and may now be threatened with widespread commercial if not biological extinction. MacKinnon and MacKinnon (1986) noted that the original areas of ironwood forests in Borneo were estimated to cover 1,440 km², but that now only about 40 per cent of these areas remains (MacKinnon & Artha 1981; MacKinnon & MacKinnon 1986 in MacKinnon et al. 1996)

Despite the good intentions of some authorities responsible for forest management and a formally protected status, ironwood has become a vulnerable species. Indeed, there are fears of total depletion within two or three decades if no effective counter-action is taken. Since the end of the nineteenth century, Indonesia's human population has increased from a little more than ten million to its current population of over two hundred million people, while lowland forest - ironwood habitat - has dwindled dramatically. In addition, the best quality wood is that with the straightest grains, a quality that takes hundreds of years to acquire.

1.3. The protected status of Borneo ironwood

Most of the world population of Borneo ironwood trees is to be found in the Republic of Indonesia; the remainder occurs in the Eastern (Bornean) states of the Malaysian federation (Sabah and Sarawak). Population reduction caused by overexploitation and forest conversion has been noted in the following regions: Kalimantan, Sumatera, Sabah, Sarawak and the Philippines. Since ironwood is strong and extremely durable, it is in great demand and heavy exploitation has led to commercial stands.

The IUCN Global Red List of Threatened Species is the best-known worldwide conservation status listing and ranking system. The system divides threatened species into three categories of threat (IUCN 2010): Critically Endangered (CR), Endangered (EN), and Vulnerable (VU). The list also listed documents those extinctions that have occurred since 1500 AD and taxa that are extinct in the wild. Lower risk taxa are also divided into categories. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival (IUCN 2010).

Borneo ironwood was included on a shortlist of endangered species of Indonesia (Anonymous 1978). It has also been included in a list of vanishing timber species in the Philippines (de Guzman 1975). According Tantra (1983), ironwood is considered to be 'vulnerable to extinction' in Indonesia. By the late 1990s, ironwood trees with a large diameter were seldom observed in Kalimantan. Particularly in Sumatra this species has been reported to be almost extinct (Soerianegara & Lemmens 1993) and on the flat lowlands of southern Sumatra, once great stands of ironwood have now been almost entirely destroyed (WWF & IUCN 1995). Already in the early nineties, the species was categorized as 'vulnerable' because of the heavy logging and habitat destruction (Soerianegara & Lemmens 1993) and it has been included in the Red List of threatened trees of Indonesia since 1994 (IUCN 2003). In parts of Kalimantan, this species is already considered to be regionally endangered (MacKinnon et al. 1996). The decrease in growing stock is due to exploitation beyond the growth. In Indonesia, Borneo ironwood is under varying degrees of threat of extinction (BAPPENAS 2003). This species is considered to be almost extinct in Sabah (UNEP-WCMC 2007). According to the World Conservation Union and the 2010 IUCN Red List of threatened species (IUCN 2010), Borneo ironwood is one of many species of tropical hardwood tree classified as a 'vulnerable' species across its range (VU A1cd+2cd). However, it has not yet included in the CITES appendix.

In an effort to sustain the genetic resources of commercial species such as ironwood, the Indonesian Minister of Agriculture issued the Decrees No. 54/Kpts/Um/2/1972 and No. 261/Kpts-IV/1990, which set a minimum cutting diameter for a number of important species. The species are not allowed to be cut before reaching the minimum size determined in the Decree (see Appendix 2). The Indonesian endangered animal and plant lists have been compiled and presented in a 2001 publication *Jenis – jenis Hayati yang Dilindungi Perundang-undangan Indonesia* (eds M. Noerdjito & M. Maryanto 2001). Species named in this publication are officially recognized as 'threatened with Extinction'; that is to say, their threatened status is supported by a ministerial decision or *Surat Keputusan Menteri*. Another publication for plants *Tumbuh-tumbuhan Langka di Indonesia* by Mogeia et al. (2001) provides further information and also includes some proposed additions to the list of threatened plants. A list of threatened species presented in the Statistics Report of MoF presents much lower figures for numbers of endangered species than Noerdjito and Maryanto (2001).

1.4. Ecology and natural history

1.4.1. Geographical distribution

Geographical distribution

Borneo ironwood has a wide geographical distribution and its natural stands in natural habitat are distributed in the south of Sumatra, Bangka Island and Belitung, Borneo (Kalimantan, Sarawak, Sabah and Brunei Darussalam), stretching across as far as the Philippines, the Sulu Islands, Palawan Island and nearby small islands (Fig 2.1). Within Indonesia, ironwood is virtually confined to the island of Sumatra and Kalimantan. Browne (1955) noted that the patchy distribution, limited extent and inaccessibility of many ironwood forests in Serawak made an assessment of remaining stands and sustained yield management very difficult. MacKinnon and Artha (1981) noted that in Kalimantan only 30 per cent of the original area of this habitat type remains, and most of this is very disturbed as ironwood trees have been logged selectively and removed.



Figure 1.1. Distribution of Borneo ironwood

Source: www.reliefweb.int

Morphology

Widyatmoko and Susanto (2004) have identified that ironwood tree height is up to 35m and it can grow up to 40m tall, with a clear bole length of 5 to 20m. The diameter is up to 100cm, sometimes up to 150cm; the buttress is up to 4m high, 10m wide and 15 to 40cm thick. Its leaves are arranged spirally and are not scale-like; they are simple, flushing red. Ironwood fruit is berry-like, long ellipsoid and hard. It produces one seed per fruit, which is between 5 and 15cm long. Widyatmoko and Susanto (2004) also stated that flowering can occur throughout the year depending on location and climate. The flowers bloom from August to November in Palembang; in July in Jambi; April, June, August, November, December in Belitung; and October and November in south Kalimantan. Maturity from flower to seed may be as little as three months. The peak of seed harvesting is at the beginning or in the middle of the wet season. The outer bark of the ironwood is reddish brown to dark brown or grey-brown, 2 to 9 cm thick, sometimes with shallow grooves; it peels off abundantly in small and thin pieces. Figure 1.2 shows an ironwood tree, its seeds, leaves and fruit.

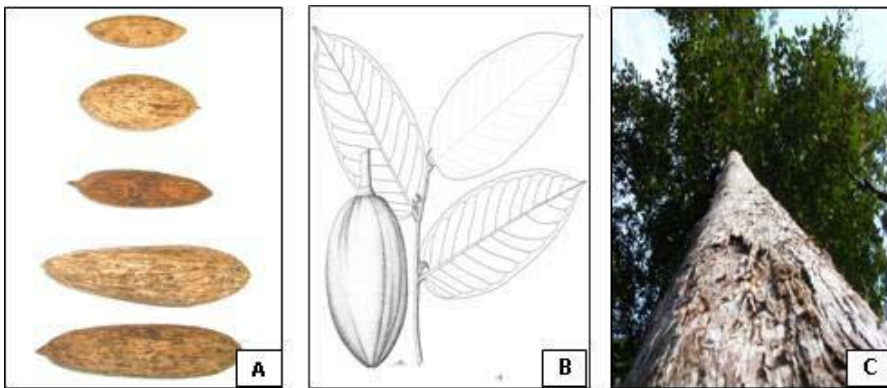


Figure 1.2. (A) Various forms and size of ironwood seed; (B) Description of *Eusideroxylon zwageri* T e B: Leaves and the fruit (Kefler & Sidiyasa 1994); (C) Rear of a Borneo ironwood tree (Photo: Wahyuni)

Traditionally, forest trees and products are acknowledged as valuable resources by tribal people in Asia, commonly forest dwellers or forest-edge communities. Ironwood varieties have been recognised by Paser and Dayak indigenous people in East Kalimantan (see chapters 3 and 4 of this research) and in Jambi, Sumatra (Irawan & Gruber 2003). The variability of ironwood has been reported by many scientists since the mid-nineteenth century (in Kostermans et al. 1994; Van Lijnden & Groll 1851; Teijsmann 1858; Teijsmann & Binnendijk 1863; Heyne 1927; Koopman & Verhoef 1938; De Wit 1949). However, these observers were unable to give further causal explanation for this

variability. Indeed, most only reported the variability, which was recognised by local or native people based on certain morphological structures, such as fruit form or bark and wood characteristics (see appendix, table 1).

The ironwood tree has large leaves and heavy fruits, like large nuts, which litter the forest floor. Ironwood seeds have various forms and size and each variety has specific seed characteristics. The seed, the largest of all dicotyledon seeds, is about 14cm long, weighs about 230g, is grey-green in colour, has a stony drupe and is ovoid like a rugby ball. The tree often produces a sprout of over 1m tall before the leaves develop (MacKinnon et al. 1996).

Irawan and Gruber (2003) have also identified the leaf form of each variety of ironwood from Jambi, Sumatra. Their research reveals that the leaf form of this ironwood variety shows large variation. Its leaves alternate between simple, penni-veined, and glabrous to slightly hairy below. The forms of *sirap*'s leaves are oblong to elliptic. The leaves of the *tanduk*'s and the *daging*'s tend to be obovate while *kapur*'s leaves tend to be ovate. The *kapur* also stands out as – having a bark surface with a distinct form and colour – it is smooth and has a white colour that is not be found on any other variety.

1.4.2. Role of the species in its ecosystem

A nondipterocarp, Borneo ironwood is a tree of the tropical rainforest zone. MacKinnon et al. (1996) stated that in Kalimantan, ironwood is originally a common species occurring in lowland areas of primary forest areas between 5-6,400m altitude, in flat or sloping terrain. It also occurs in old secondary forests (Suselo 1987). This species has a slow growth and is a highly valued tree species that is found locally in dense stands and in undisturbed mixed dipterocarp forests up to 600m altitude. In Borneo, its natural stands are a scattered component of the Dipterocarp forest or are gregarious, and in some localities it forms a single dominant variant, sometimes forming pure stands, e.g. in Sumatra (Masano & Omon 1983; Irawan & Gruber 2003). The 'ironwood forest' is recognised as a distinct type of lowland dipterocarp forest, characterised by exceptionally low species diversity. This formation can vary in composition from site to site and from island to island. In these formations, ironwood is usually the main canopy and is especially found on sandy well-drained soil with a wet climate, on clay soil, on tough clay soils and on hills up to 600m above sea level with a density of 4-8 trees/ha. In addition, it is prevalent on slopes in alluvial soil near rivers. It can grow solitary or in groups. Soil carrying ironwood forests contain a high proportion of sand or clay. In secondary forests, this tree is usually present as a pre-disturbance remnant tree. High quality trees occur in certain riparian communities scattered through the extensive lowland Dipterocarp forests of Borneo. Lower qualities of the wood are scattered across associated hillsides. Scattered trees also occur on clay hillsides up to 360m (MacKinnon et al. 1996).

Kostermans et al. (1994) reported that most ironwood forests occur near rivers banks and adjacent hills, but they are also found on pure sand. Furthermore, the vicinity of a river is not necessary if the soil consists of loamy sand. In addition, ironwood grows well in damp soil, however, ironwood always avoids soils that are temporarily inundated, marshy or water-logged. Primary forests often contain larger or smaller groups of ironwood but they do not belong to giant forest trees. Ironwood grows well in humid climates and it also could grow in places with short dry seasons (Kostermans et al. 1994). In addition, Soerianegara (1974) reported that ironwood could be found in areas with dry sub-humid climates and humid climates with precipitation between 2,000 to 6,000mm per year. Soedibja (1952) stated in Irawan (2005) that ironwood is a shade-bearer species when immature.

Ironwood trees in Borneo do not form a distinctive, monodominant forest, unlike the ironwood forests in Sumatra, where researchers found that 81 out of the 84 trees in a half-hectare patch had a diameter at breast height (DBH) greater than 15cm (Whitten et al. 1987). As with other tropical wood species, only a few individuals occur per hectare. Small stands may become dominant to form a distinct forest type in association with dipterocarp species (MacKinnon et al. 1996). Densities for ironwood are estimated at 33 trees of over 20cm DBH per hectare at one site in Kalimantan (MacKinnon et al. 1996; see also Chapter 3 for density of ironwood trees of over 10cm). In West Kalimantan, natural stands of ironwood are grown successfully alongside *Shorea parvifolia*, *Koompassia excelsa* and *Dehaasia* sp (Sidiyasa 1995), while in the Sungai Wain Protection Forest in East Kalimantan, natural stands of ironwood are found alongside other species, like *Dipterocarpus tempehes*, *Madhuca kingiana* and *Shorea johorensis* (Keßler 2000). According to the same author, Kutai National Park is the best-known habitat for ironwood in East Kalimantan. Mixed *ulin-meranti-kapur* forests occur on poor to moderately well-drained soils in the western half of the park (MacKinnon et al. 1996) and in some places in Kutai this species can be found in dominant stands. The ironwood grows successfully in mixed stands and close to *Koordersiodendron pinnatum*, *Shorea* spp, *Dracontomelon dao*, *Dillenia excelsa* and *Syzygium* spp. Unfortunately, there are considerable threats the existence of Kutai National Park. Of the total area of 198,629 ha, only a small part of this park remains under natural forest (WWF 1985). The majority of the park consists of burned area and cleared forest. In Sabah, ironwood can be found in the Tabin Wildlife Reserve (UNEP-WCMC & GTC 2003, 2006). According to Irawan & Gruber (2003), ironwood in the natural forest of Senami Forest in Jambi grows in association with more than a hundred tree species including *Palaquium hasseltii*, *Ochanostachys amentacea* and *Shorea* spp. Ninety-nine species have been recorded at the tree stage in this forest. At the pole stage, ironwood grows associatively with 90 species. At sapling stage, it grows with 125 species, while at seedling stage ironwood grows with 92 species.

Naturally regenerated seedlings are usually restricted to the area near seed parents and poor seedlings regeneration in logged-over forests has been noted by Kartawinata (1978). Regeneration in logged-over forests is often not sufficient, although ironwood

may coppice freely and can then be persistent. Ironwood seedlings seldom die in a closed rain forest. However, as they grow slowly, natural regeneration appears to be poor in terms of timber production. Canopy opening and weeding (release cutting) accelerate seedling growth by improving the light conditions (Kiyono & Hastaniah 1997). In South Kalimantan, ironwood seedlings often dominate regeneration in virgin forest, together with Meranti, but in logged-over forest regeneration of ironwood is often considerably less prolific (Soerianegara & Lemmens 1994).

Delmy (2001) reported that several tree species are promoted by fire or are more fire resistant than others, while others will be suppressed. He also reported that species are classified as fire resistant when they appeared in the different strata independent of fire intensity. Ironwood is one of the tree species that has the resistance to survive fire, as well as *Borassodendron borneensis*, *Koordersiodendron pinnatum*, *Alstonia* sp., *Dyera* sp. and *Diospyros* spp (Leighton & Wirawan 1986; Tagawa et al. 1988; Wirawan 1985). Sprouts will generally appear if the plant suffers severe disturbance of its growth, e.g. damage by forest fire or logging operations. Only certain tree species can produce sprouts naturally and it seems to depend on environmental factors such as degree of damage, humidity and temperature. Among 20 sprouted tree species, Borneo ironwood is prominent, followed by *Litsea* sp., *Durio carinatus*, *Gironniera nervosa* and *Diospyros curaniopsis*. Ironwood produces sprouts easily and no dead trees were found (Delmy 2001). According Beekman 1949, in Irawan & Gruber (2003), it can also produce about 10-20 sprouts on each tree and these sprouts drop when their stem diameter reaches 20cm. Sprouting is very important for ironwood since the species faces serious threats. It is very important for regeneration, stand restoration, genetic resource conservation, propagation and development of ironwood.

1.4.3. Features of the wood

Ironwood trees have wood that does not float in water but sinks (Soerianegara & Lemmens 1993). It has the densest, heaviest wood of any native tree in Kalimantan. Indeed, it is perhaps the hardest, most dense tropical hardwood. Because of its weight, the lack of roads into remote areas and the fact that it is too dense and heavy to transport by water, ironwood is seldom cut for sale.

Ironwood has a special physical characteristic, namely, its great strength and extreme durability. It has a specific gravity of between 0.88 and 1.19 (Soerianegara & Lemmens 1993) and a density of 835 - 1,185 kg/m³ air dried (Martawijaya et al. 1989). Although it is quite heavy, ironwood has excellent physical properties and is not vulnerable to termites or other tropical wood-eating insects or fungus. Syafii et al. (1985), in Irawan & Gruber (2003), reported that ironwood produces very dense, termite resistant silica, and its durability is primarily caused by the existence of *Eusiderin* (neolignan component) in the heartwood extractives. Additionally, Syafii et al. (1985)

describes this wood as containing lignin, primarily comprising *guaiacyl* units, which is unusual for typical hardwoods. This makes ironwood valuable for construction (Salasfky 1993). To assess the influence of the lignin structure on the rate of decay, these unusual hardwoods were subjected to decay by white-rot fungus (*Coriolus versicolor*). The results indicated that hardwoods containing guaiacyl-rich lignin are more resistant than those containing syringyl-rich lignin.

As mentioned, ironwood timber is exceptionally hard and heavy and it has been classified under the category 'Heavy Hardwood'. Syafii et al. (1985) describes that despite its high density it produces a smooth and often lustrous surface and is easy to work. However, even though there is little silica present, residue may occur on saws and machining knives after sawing. The heartwood is yellow-brown, gradually turning reddish black-brown when freshly sawn (Martawijaya et al. 1989). The heartwood is extremely resistant to preservative treatment. The sapwood is light yellow-brown when fresh and darkens on exposure to deep reddish brown, becoming very dark brown or almost black with age. There is a distinct border between the sapwood the heartwood, anything between 1 and 5cm, generally 3cm thick. The texture is rather coarse, even when the grain is fairly straight or shallowly interlocked. The wood surface is smooth. Alternating dark and rather light coloured streaks are faintly visible on the radial section (Martawijaya et al. 1989). Fresh ironwood has a sour or rather acidic smell resembling that of cedar wood, which gradually disappears. The wood has a very low shrinkage rate and is susceptible to lyctid borer attack.

1.4.4. Threats and impact on ironwood population

Peluso (1992) reported that much of the ironwood on Borneo has been overextracted by timber concessions and exploited in logged-over forests. The introduction of chain-saws and extensive road systems by the timber industry, together with the conversion of forests to oil palm plantations and timber estates, has accelerated this process of over-exploitation, especially since the 1998-1999 economic crisis. All of this has culminated in the decline of this slow-growing timber species (Peluso 1992; WWF 2001). The increased availability of forest roads opened by concessionaires is leading to greater problems of uncontrollable exploitation in Kalimantan (Partomihardjo 1987).

In 2003, Irawan and Gruber reported that a clear example of ironwood degradation can be seen in the Senami forest. Senami is one of a number of forest areas in Jambi province, Sumatra that was once dominated by the ironwood species. They also reported that the mean volume of ironwood was 105.6 m³/ha, while in 1983 Masano and Omon recorded that the mean volume of ironwood was 120.9 m³/ha for undisturbed forest. The difference in the two figures indicates a significant decline in volume. From an ecological point of view, after 25 to 30 years the stem of a new ironwood tree is not thicker than 10cm, while it only starts flowering after 50 to 60 years. Under undisturbed

conditions the tree is estimated to have an average life of 250 years (MacKinnon et al. 1996). Ironwood stands are therefore vulnerable to over-exploitation when cut at a rapid pace.

Kalimantan suffers heavily from illegal logging and cutting which has encroached deep into protected areas such as Kutai National Park in East Kalimantan. As well as being a major threat, this encroachment into national parks indicates the scarcity of the species outside the protected areas.

1.4.5. Utilisation and trade

Ironwood is one of the most renowned timber species of Borneo. It has been favoured both for local use and for export trade. This rare tree is extremely hard, which makes it useful for many products on both a local and industrial scale. A wide range of products can be made from ironwood. The Dayak, an indigenous peoples of Borneo, know well the valuable qualities of ironwood. They recognise its strength and durability, particularly when exposed to the elements (Salam 2007). Traditionally, Dayak communities in the interior of Borneo use ironwood for poles and beams, blowpipes, *sirap* tiles for the roofs of their house, the pole of their spears and making handicrafts and souvenirs. Ironwood is also used in ritual and a carving wood for statues and household utensils. In addition, ironwood charcoal produces the best ink for the Dayak's tattoos. In Java, ironwood has been used for railway sleepers and poles for electrical wire since colonial times. Ironwood poles are also used and act as support (*turus*) for local climbing pepper plants. Indeed, since the 1970s, farmers have settled alongside the roadways near Bukit Soeharto in East Kalimantan, and started pepper farming using ironwood support stakes (Kiyono & Hastaniah 1997). Ironwood is esteemed by the Chinese as a coffin wood. Besides its use in house-building and heavy construction, an ethnobotanical database by Duke (1991) (see www.ars-grin.gov) suggests that the chemical(s) found in ironwood are used for medication. Certainly, traditionally, the seed of the ironwood fruit has been used as a salve for swellings on the skin (Soerianegara & Lemmens 1994). And, when boiled, the liquid extracted from young ironwood is often smeared on the skull. It is said to be a good hair tonic, not only keeping the hair healthy, but also black. Ironwood has also been used locally as a traditional cure for toothache (Ajizah et al. 2007). Kartawinata et al. (1981) noted that transmigrants settlers in East Kalimantan cut this species for sale in order to supplement their income. In Southern Kalimantan ironwood timber is felled by the owners of concession rights and also by local people coordinated by ironwood traders (Partomihardjo 1987). Here the average demand for ironwood by the sawmill industry was, on average, about 50,202 m³ per year during 1998-1999 (Wahyuni & Gunawan 2000).

The warm, red wood can resist rotting for 40 years, or, in dry condition, for up to a century (MacKinnon et al. 1996). Presently, ironwood is valued by people everywhere in Kalimantan for its extremely important and varied use in technology. The dark timber is a highly prized wood and suitable for making building foundation, houses and widely used for all heavy constructional work, railway sleepers, mallets, window and door frames, heavy duty industrial flooring, decking, printing blocks and wood shingles. Furthermore, it can also be used in submerged constructions such as bridges structures, marine work, boat construction (Salam 2007), piers or quays, shipping industries, outdoor furniture, vehicle body work and other tasks where high strength and durability are required. In Kalimantan ironwood is especially sought after for making roof shingles (*sirap*) and poles for pepper plantation and survey pegs. In terms of shingles material, normally ironwood that has straight fibres, which will crack slightly, will be chosen.

Currently, ironwood is used for modern processed products such as heavy duty industrial flooring, decking, letis, and printing blocks for export purposes. Although trade and export of ironwood are forbidden under Indonesian law, in reality many companies have exported modern processed products made from ironwood to consuming countries (see Chapter 6 of this research). Indonesia has a total prohibition on the export of ironwood and cutting is restricted to trees with a less than 60cm DBH.

1.5. A history of ironwood exploitation and its trade

1.5.1. Early ironwood exploitation and its trade

There is no doubt that timber was in great abundance in Borneo in the (colonial) past. Indeed, timber was one of the forest products traded internationally from Borneo's tropical forests since somewhere in the thirteenth century (Nicholl 1989). During the colonial regime, from 1650 to the late-nineteen century, deforestation was concentrated within the most accessible regions of many Indonesian islands. Logging was undertaken primarily for shipbuilding and secondarily for local furniture making. Indonesian timber was an indispensable shipbuilding material for the colonizers, who used it for trade and in their battles for conquests (Knapen 2001). Ironwood exploitation has a long history in Kalimantan as both a commercial and a subsistence forest product and it was already important during Dutch colonial times. As we have previously seen, ironwood was in high demand because of its extreme durability and strength. Knapen (2001) reports that at the end of the eighteenth century, in a bid to make the Kalimantan town of Banjarmasin self-sufficient in timber, the Dutch sought new methods of retrieving vast amount of wood from the forest, including imposing taxes on the Dayak in the form of ironwood. In 1788, the Ngaju people of the Kapuas area of Kalimantan supplied an unprecedented 1,000 poles of ironwood as part of the demanded payments and, for a few years, more deliveries followed.

Sellato (2001) reported that early forms of timber trade in the Southeast Asian archipelago were concentrated in a few areas and conducted under a socio-political structure largely based on control of main access routes by rulers who held titles such as sultan or king. The sultanates or kingdoms of these rulers consisted of little more than small settlements at the mouth of important river routes where it was possible to control and collect taxes from this trade. For a significant part, the procurement and trade of forest products defined the socio-political organisation of entire regions where timber originated. For instance, the coastal economy of East Borneo, which for centuries was based primarily on melted iron and gold, and on forest product extraction and trade (Andaya et al. 1981; Peluso 1983), was dominated by sultanates and what Sellato (2001) identifies as 'petty' kingdoms. According to Peluso (1983), these sultans and kings had, since about the thirteenth century, come mostly from Java. This coincided with a change in the regional trade politics that was largely dominated by China's recognition of Srivijaya as its main Southeast Asian trading partner. The Srivijaya kingdom, which flourished in western Sumatra between the eighth and twelfth centuries (Andaya et al. 1981) held exclusive trading rights with China, the largest trading destination of much of the exports from Southeast Asia. During that time, Chinese, Bugis and merchants from several other ethnic groups controlled the trade networks beyond the interior and coastal sultanates and kingdoms. This control persisted for much of the pre-colonial period.

In East Kalimantan, for instance, for a long time the Kutai operated as middlemen between the interior Dayak and the Bugis traders (Sellato 2001). They apparently went upriver to trade themselves, sent their agents, or received goods sent by inland chiefs. The sultans levied taxes, not so much because they considered themselves owners of the areas where forest product grew, but rather because they controlled vital parts of the transportation system. For the most part, upstream groups remained autonomous and eventually rebelled, fearing that any downstream ruler would force them to direct their trade his way, impose heavy duties, or expect them to pay tribute in the form of rice and forest products (Sellato 2001).

Trade in forest products from Kalimantan intensified from the seventeenth century onwards (Sellato 2001). This coincided with the Sulu kingdom (formerly a vassal of Brunei) taking of the control of the trade of the northern half of Borneo. The Chinese and several ethnic groups from the archipelago remained in charge of the trade, but later it became dominated by the Bugis. The Bugis, who originated from Sulawesi, initially spread to Java, Palembang and Jambi following conflicts in Sulawesi, partly fostered by the Dutch in a bid to increase their control of the island and the region (Andaya et al. 1981). These refugees came into conflict with local authorities and eventually moved on to remoter places like the southwest and east coast of Borneo. The Bugis traders gained considerable political power because of their seafaring skills and trade connections. Eventually, the Dutch took control of the forest product trade, but not until the twentieth century. The fight over direct control of the forest product source areas

also intensified once downstream demand increased. Marriage and blood brotherhood became common ways to bind tribal groups to downriver kingdoms (Sellato 2001). In East Kalimantan, for instance, the Taogus, one of a number of the groups in the region, tried to intermarry with the native women in order to increase control of birds'- nests caves. However, this was largely unsuccessful because, by that time, the Kenyah, one of the more powerful interior Dayak groups had seized control of some of the forest product resource areas.

Ironwood has been a trade commodity for centuries; ever since Dutch, Chinese, Makassar, Bugis and other wandering traders first came to Kalimantan. In 1790, the durability of ironwood had drawn the attention of the colonial government in Batavia. The colonial government wanted more information on the timbers of Borneo in order to determine 'whether this timber can also be usefully employed at other locations'. Although the Dutch gradually took control of Java and Sumatra, the Bugis continued to maintain control of the trade with the coastal towns of Kalimantan throughout the eighteenth century. The trade of ironwood timber, which involved Kalimantan and Sulawesi, has continued for more than a century. This trade has been determined by the presence of the Bugis on both islands. The Wajorese (Bugis) have been in Pasir, Samarinda, Kutai and Banjarmasin since 1668, a year after the signing of the Bongaya Treaty, which marked the defeat of their ally Gowa-Tallo in the Makassar War (1666-1669) with the Dutch-Bone allies.

Potter (2005) reports that a few species were singled out by the Dutch as particularly valuable and warranting particular attention. The slow-growing Borneo ironwood, known as *ulin*, *belian*, *telien* or *tebelian*, which was used for heavy construction, such as wharfs, boats, all government buildings and most longhouses, was perceived as belonging to this category (Potter 2005). Indeed, the timber was advertised at the 1886 Colonial Exhibition in London alongside other timbers such as *Borneo Mahogany*, *Borneo Walnut*, and *Borneo Cedar*, names specifically chosen to attract the attention of foreign buyers (Potter 2005).

Knapen (2001) reports that both the Banjarese and Dayak tribal groups in Kalimantan widely used ironwood for the construction of dugouts and larger types of boats, and as a building material in and around their settlements. Taxes demanded by the sultan and colonial powers often included deliveries of this valuable timber. At the end of the eighteenth century and again in the 1820s and 1830s, the Dutch in Southeast Borneo attempted to secure ironwood by making up-river Dayak pay taxes in the form of ironwood rafts (Knapen 2001).

In 1974, John Crawford reported that, as early as 1829, the Chinese exported Borneo ironwood to China. The exploitation of timber in North Borneo was already a well-practiced activity at that time, but it increased markedly towards the end of the nineteenth century as a result of the expansion of railway networks in China, which raised the demand for ironwood sleepers. The valuable ironwood timber was cut (and

squared if necessary) by indigenous people and Chinese workers and hauled by buffaloes or by manual means to the rivers where it was rafted to Sandakan Bay to be exported. If, in 1883, there was only one large timber company in the territory, 'by 1886 there were five concerns involved in the timber trade'. It was during those early years of increased demand for ironwood that Sandakan emerged as an important timber centre in North Borneo (Obidzinski 2003).

Knapen (2001) also reports that the number of manual sawmills, mainly worked by debt-slaves, was growing, particularly in Negara and Banjarmasin. Wood cutting remained a small-scale, local affair, without any government regulation. The food shortages in Murung at the end of 1875 were of some importance to the Dutch. They resulted in a precarious situation which the Dutch successfully exploited to procure ironwood for the construction of their new warehouses in Banjarmasin in return for rice or cash.

In the early 1900s, KPM (*Koninklijke Paketvaart Maatschappij*, Royal Shipping Company) ships came to Berau every month to take cargoes of ironwood for transport to Makassar, Banjarmasin and Java. The Java-China-Japan shipping company also frequented Berau for ironwood and rattan, both of which were exported mainly to Shanghai. Finally, even ships from the timber-rich territory of British North Borneo made monthly trips to Berau to pick up ironwood for shipment to Hong Kong (Obidzinski 2003). The extraction of ironwood in Berau at that time, although intensifying, continued to be a cottage industry that in terms of real value, was secondary to dominant non-timber forest products such as birds'- nests, gold and reptile skins (Noor 1996). By 1914, 80 per cent of timber floating down the Barito was export. Moreover, both non-timber and timber products were subject to a 10 per cent tax (*cukai*) by the sultans.

Wadley (2005) reports that from about 1916 there was a good deal of forestry activity as the various territories gradually set up official forest services in order to study and map the resource and to encourage more harvesting of timber for export. Wadley (2005) noted that with strong commercial orientation, British North Borneo was the most successful exporter of raw logs, initially mainly to Hong Kong. The British North Borneo Company was active in pursuing forest policies partly modelled on those of the American Philippines, which included experiments in the use of high lead logging³ together with rails for transporting timber. However, such methods were later found to be uneconomic and they were dropped towards the end of the 1930s (John 1974). At the same time, such techniques began to be used in Dutch Borneo, with the establishment of a few Japanese concessions on the east coast. The scope and scale of forest exploitation changed slowly, from an exclusive interest in high value timbers, such as ironwood, to a growing concentration on the dipterocarps, despite their susceptibility to the teredo worm (*Teredo navalis*). In South and East Borneo the focus of forestry activity gradually moved from the ironwood complexes of the Meratus Mountains to the enormous

3 High lead logging is a method of cable logging using a spar (tree), yarder and loader. It was developed by Oscar Wirkkala and is accomplished using two lines (cables) and two winches.

dipterocarp reserves of the Mahakam basin and as far north as Tarakan (Potter 1988). In Sarawak, cutting focused on the Rejang Basin but was still largely confined to ironwood, following some disastrous failures with dipterocarp logs that rotted in the forests.

New products came into heavy demand in the last twenty years of the nineteenth century, mostly from the industrialising Western world. Certainly, this period corresponds with the increasing Dutch efforts to control regional trade. The perceived value of the forests changed, from an early concentration on slow-growing, hard and naturally borer resistant timbers, such as ironwood, to an eventual appreciation of a few ubiquitous dipterocarps, especially the Shoreas, for example *Shorea leprosula* (Wadley 2005). Brookfield et al. 1995 and Peluso 1993 in Knapen (2001) report that in the course of the twentieth century, techniques to penetrate the forest greatly improved and the ironwood could be hauled from increasingly remote locations. Buffaloes were becoming more widespread, and logging roads and towing trails penetrated deeper into the forest than ever before.

1.5.2. Ironwood trade in a free Indonesia

Ironwood has long been an important product of the old growth forest and is traded and collected from natural forest. According Potter (2005) that before world war two and in the early post-war years most tropical hardwood timber entering world trade came from countries bordering the Atlantic Ocean. In addition, demand for Southeast Asian timbers was selective, with a particular emphasis on teak and on certain species with great construction value such as the Borneo ironwood.

Indonesia declared independence in 1945, and a formal agreement was reached in 1949. The first years after independence featured an ideology of reinforcing the rights and opportunities of those who had hitherto been oppressed. The new nation formulated a number of important laws and regulations to deal with its forests and its forest resources. Several of these laws created opportunities for the legally recognised exploitation of forest products by local groups. The constitution, formulated soon after independence, declared all natural resources to be the property of the state and prescribed that they be used for the maximum prosperity of the people (Weinstock & Sunito 1989). Provincial and district governments were given the right to grant permission to collect timber and non-timber products in the new nation's forests. The era of sultans and kings was definitely over. Their roles in the forest product trade had effectively ended. The non-indigenous traders were viewed with suspicion, and they had little opportunity to continue their profession through the first years of independent Indonesia.

In the lowland forest of Kalimantan, ironwood trees have been cut, logged and harvested in order to fulfill the demand for heavy construction and manufacturing products. In four provinces of Kalimantan, ironwood timber is in demand because it is used substantially in house building (Anonymous 2004b). Initially, since the

1950s, ironwood has been used by local enterprises that require the high strength and durability of the timber. Partomihardjo (1987) also added that the use of ironwood for heavy construction became particularly important in the 1970s. The commercial trade in ironwood has been carried out since at least 1960s and is a trade that expanded rapidly (Salam 2007). Salam (2007) reports that intensive ironwood trading between Kalimantan and Sulawesi began in the 1950s, reached a peak in the 1970 and has shown a constant decline in the last five years. Ironwood has been used for boatbuilding in the Spermonde Archipelago since the 1970s. Since the 1990s, Salam (2007) noted that ironwood has been used for construction of the whole ship, with only a small degree of non-ironwood substitution. The various and broad range of uses of the wood have stimulated a high demand and, in turn, increased the volume of trade. Since 1996, ironwood has been processed as an added-value product for decorative and moulding wood materials. In the last decade, the demand and popularity of ironwood has augmented (see chapter 6 of this research). The demand was at its highest peak during the 1970s and continued until about 1997 when an economic crisis kick-started its decline, which persists to this day.

1.6. A history of ironwood conservation

Nature conservation in Southeast Asia has been incidental and poorly organised (Jepson & Whittaker 2002). It was, and still is, a political side-issue. Conservation policy is conducted by a bureaucracy typically embedded in a government structure whose primary aim is the exploitation of natural resources and the use of land for cash-crop production. Even in colonial Indonesia, conservation measures would probably not have been on the agenda had it not been for the vigorous lobbying and active booster activities of the Netherlands-Indies Society for Nature Protection, as well as the commitment of a few colonial staff members of '*Land Plantentuin*' (i.e. the Botanical Gardens) (Jepson & Whittaker 2002).

What has been done to preserve the ironwood forests in the past? Knapen (2001) reports that protection of this tree species in Indonesia goes back to the colonial era, when, in the 1850s, the idea had taken root within the colonial government that the cutting and replanting of ironwood trees should be encouraged in order that the tree would remain available in the future. Later, the necessity for safeguarding supplies to town led to a system of licenced cutting and replanting, whereby the feller was supposed to replant twice the number of cut trees. This worked at least in the more accessible forests and was extended to a few other 'useful' timber species. No case of replanting has ever been reported, however, which must have been due to the fact that there was no form of control whatsoever (Knapen 2001).

Around 1850, the accessible and harvestable stands of ironwood along the Barito river and in Hulu Sungai province (South and West Kalimantan) had all been cut, and

that only in the upper Kahayan, and probably the Kapuas, was the situation said to be more favourable. Indeed, large beams and entire logs were seldom seen any more in Banjarmasin (the capital city of South Kalimantan). While the prices of timber in general were dropping after the war, the price of ironwood remained very high (Knapen 2001).

Padoch (1984) stated in Potter (2005) that in Sarawak, preventive measures were taken by the Rajah from the 1860s to control the cutting and burning of ironwood. Contrary to Sarawak, where the Brookes ruler forbade the cutting of forests containing ironwood as early as 1863 (Padoch & Peluso 1996), no attempts to control the felling of commercially attractive timber trees were seen in Southeast Borneo before the twentieth century. Only at the turn of the century, when government regulations already in force in Sumatra were adopted in Southeast Borneo, was some control established and 'there was even some replanting reported'. The first signs of government-regulated forest exploitation in Southeast Borneo were visible by 1915 (Potter 1988).

At the end of the nineteenth century there was only one location where ironwood was said to have become entirely extinct: the lowlands of the Hulu Sungai in Southeast Borneo, where the tree used to be found on more elevated lands (Schophuys 1936 in Knapen 2001). Knapen (2001) noted that timber industries, increasingly shipped in their ironwood from upriver regions. In the surrounding areas, such as the Meratus mountains (the mountains between South Kalimantan and East Kalimantan), ironwood was said to be very scarce and limited to the least accessible upriver areas. However, considering the protracted human exploitation of the ironwood forests, it is safe to assume that these forests showed clear signs of degradation.

In Sarawak, planting of local species *Eusideroxylon zwageri* and *Shorea macrophylla* started in 1936 during the British era. Over thirty years ago, the scarcity of ironwood in Sarawak was noted by Browne (1955), who pointed out that, 'Our surviving supplies of ironwood are by no means very large and are undoubted dwindling'. The main causes given for this are shifting cultivation and wasteful use. More recently, conservation efforts have been attempted in order to conserve supplies of this species in Sarawak (Asia Regional Workshop 1997). Under the Forest Rules of Sarawak, export of ironwood in log, sawn or hewn form is not allowed without special permission. Strict regulations for logging of the species are in place and export controls have been in force since 1950. Ironwood was planted in experimental planting in Malaysia in 1959 together with other species such as *Dryobalanops aromatica*, *Flindersia brayleyana*, *Fragraea fragrans*, *Khaya* spp., *Pentaspadon officinalis* and *Shorea macrophylla*. In Indonesia, *ex situ*, ironwood adapts well, such as in the Trial Garden at The Centre for Research and Development of Forest and Nature Conservation in Bogor. Indeed, there is a single tree in this garden that is about fifty years old, with a height of about 20m and a stem diameter reaching 30cm.

Forest exploitation and management plans played a role in the conservation measures for ironwood stands. The inventory of forest resources that formed the second major part of the forestry plan was carried out in a variety of ways. In some parts of the country, particularly in the peat swamps, the work was greatly facilitated by aerial photographs, which allowed the principal forest types to be easily detected. This was followed by mapping from these photographs with adequate ground checks, and the growing stock was assessed by random sampling in selected areas. In the inland forests, systematic sampling was necessary because there was frequently a patchwork of various forest types even within small areas. Inventories were also necessary to determine if certain species were in danger of being overlogged. (This had been the case for Borneo ironwood, which had become scarce in certain areas.)

1.7. A history of silvicultural⁴ research in Indonesia and the context of community forest

The appointment of the first colonial foresters in 1849 not only represented the start of state-controlled professional forestry in Indonesia, but it may also be considered as the start of systematic efforts to improve the cultivation of timber trees (Wiersum 1999). At first, such silvicultural experimentation took place in an informal manner in conjunction with practical efforts to improve forest management. An official Forestry Research Institute (*Proefstation voor Het Boswezen*) was founded in 1913 in Bogor, and developed in subsequent decades into one of the main centres for forestry research in the tropics. In accordance with the prevalent forest policies, silvicultural research focused initially on teak cultivation, and in 1920 the first dissertation on this subject was published (Wiersum 1999).

Indonesia has a history of silvicultural research and for a long time the research was defined by the assumption that silvicultural management could only be carried out by professional foresters and under state control of forest lands. These assumptions focused attention almost exclusively on developing efficient techniques for the production of timber and other industrial products (Kartasubrata & Wiersum 1992). In the early half of the twentieth century, the Dutch established plantings of a number of hardwoods in Indonesia (Subiakto et al. 2001; Sidiyasa et al. 2001). The original idea was not to consider these plantations as conservation stands per se at the time of establishment they were simply meant as silvicultural trials to evaluate species for plantations. Nevertheless, these stands, many of which are now 60 years old – may provide valuable experience relating to the establishment and management of *ex situ* conservation stands. Indeed, in the literature today the Indonesian stands are often referred to as *ex situ* conservation stands (Subiakto et al. 2001; Sidiyasa et al. 2001).

⁴ The art of producing and tending a forest by manipulating its establishment, composition and growth to best fulfill the objectives of the owner. This may, or may not, include timber production.

In 1937 the Dutch Forest Research Institute, which, after independence, became the Forestry and Nature Conservation Research and Developmental Centre (FNCRDC), established eight demonstration forests in western Java, that hosts Dipterocarp collections of five genera and 41 species from Sumatra, Bangka, Java, Kalimantan and Maluku (Theilade 2003). Various studies have been conducted from these demonstration forests, including growth, yield, pest and disease and flowering patterns (Subiakto et al. 2001). The dipterocarp stands in the demonstration forests have become important seed sources for planting programmes. Thus, even though they were actually designed for research purposes, some of the plots are now considered valuable field gene banks.

The state of silvicultural knowledge at the end of the 1940s is reflected in the silvicultural textbook by Beekman (1949). More than 60 per cent of the text in this book is devoted to silvicultural descriptions of four important commercial tree species: *Tectona grandis*, *Altingia excelsa*, *Pinus merkusii* and *Eusideroxylon zwageri*. Since then, much information has been collected on additional species and important advances in the field of plantation forestry have been made, e.g. on tree breeding (Soerianegara 1974) and symbiotic relations between trees and micro-organisms (e.g. Smits 1983).

This progressive trend started to change with the Basic Agrarian Law of 1960 (Weinstock & Sunito 1989). This law allowed the possibility of overruling customary law considerations whenever national interests were at stake. The Basic Forestry Law of 1967 called for research and development of forest products for the betterment of the people living within or near the forest (Weinstock & Sunito 1989).

The 1966 decision to exploit the rainforests on other or outer islands marked an important new phase in silvicultural research (Soerianegara 1973). Attention focused on natural forests as a silvicultural model. Rather than concentrating only on artificial regeneration, attention broadened to include techniques to stimulate natural regeneration of desirable tree species, e.g. Dipterocarpaceae. An important new silvicultural principle emerged tree harvesting was not considered purely as exploitation, but also an important silvicultural practice. The research basis moved from autecological to synecological processes, with special attention to competition between tree species and synergetic relations between trees and other ecosystem components (Soerianegara 1973; Soerianegara & Kartawinata 1985; Smits 1983).

Until the 1970s, most silvicultural research focused on plantation forest as the main silvicultural model (Wiersum 1999). It concentrated on the establishment and maintenance of plantation forest, including artificial regeneration, weeding, thinning and protection against pests and diseases. Consequently, most silvicultural research on plantation forestry was dominated by the view that monocultures are technically and economically superior to mixed stands. Wiersum (1999) also suggests that since the end of the 1970s this 'worldview' underlying silvicultural research has gradually started to change and the research focus has been directed toward forestry systems providing (subsistence) products for local villagers with management responsibility in the hands

of local communities and private farmers. These new assumptions about the scope of silvicultural management has brought important changes in the general research approach, which originally was based exclusively on scientific knowledge, carried out under controlled conditions and focused on the technical feasibility of silvicultural practices (Wiersum 1999).

More interest in community forestry emerged during the seventies, when further adjustments in respect to the object of silvicultural research took place (Wiersum 1999). Attention shifted to production systems and tree species preferred by villagers, both on state forest lands or private farmlands, and including timber, fruit and multi-purpose tree species. There was a gradual realisation that there are many farmer-managed indigenous silvicultural systems present in Indonesia. Many of these indigenous silvicultural systems are characterised by mixed tree stands and/or the integration with agricultural crops. Such mixed stands are preferred by villagers, because they can provide a multitude of useful products for household needs ranging from fuel and construction wood to edible products for people and livestock and medicinal products. Furthermore, these mixed plantations provide protection against production losses due to pests, diseases and unfavourable weather. The significance of these indigenous silvicultural systems has now been acknowledged (Wiersum 1999). Several studies have described the silvicultural characteristics and dynamics of these systems (e.g. Wiersum 1982; Wienstock 1983; Soemarwoto et al., 1984; Berenschot et al., 1988; Sardjono 1990), but efforts to adapt these systems further or to develop analogous systems through silvicultural research have started only recently (Kartasubrata 1990; Bratamihardja 1990).

The research on improved silvicultural management of either natural forest or plantation forest proceeded from the assumption that the objective for management had been clearly formulated in forest policy and that it was well-understood by managers (Wiersum 1999). Furthermore, state control of forest areas assured management units in which management practices could be applied over relatively large areas. We can conclude, therefore, silvicultural research within the context of community forestry should combine scientific and indigenous knowledge. The occurrence of indigenous forest management systems is often very location specific. The identification of possibilities for improved cultivation techniques should not be based on a top down 'blue print approach'. Thus, it is necessary to carry out diagnostic surveys, to collect information about the presence and functioning of indigenous silvicultural practices and on forest management problems perceived by local people (Wiersum 1999).

There has been a global change in forestry research and development over the last quarter of a century. Westoby (1987) stated that this has transformed forestry from an ecological discipline, largely about trees and their associated biota, to one that embraces the considerations of the people who use forests or want them to be conserved. This change has been forced by practical imperatives. Oldfield (1988) reports that in many developing countries, attempting to keep people out of forests was expensive and largely unsuccessful, so that it became apparent that developing sustainable forest management,

either for productive or conservation purposes, required inclusion rather than exclusion of the people in the vicinity of the forest. As a result, Bird (1997) stated that local people who use forests are increasingly seen as legitimate stakeholders in planning forest utilisation and conservation strategies by both public and private forestry initiatives participatory forest development is in vogue.

1.8. The approach to threatened species management

Many tree species have become the focus of increasing conservation concern in recent years, primarily because of current high rates of forest clearance and over-exploitation (Newton et al. 2000). As an illustration, recent surveys have indicated that around 9,000 tree species are threatened with extinction (Oldfield et al. 1998, IUCN 2010), including more than half of the world's 600 conifer species (Farjon & Page 1999). If present trends continue, a quarter to one half of all species on earth will be extinct in the twenty-first century, and one fifth could be extinct within thirty years. Biologists attribute these extinctions to human activities, especially the destruction of plant and animal habitats (Oldfield et al. 1998, Farjon & Page 1999, Newton et al. 2000). The majority of the earth's species are dependent upon the survival of trees. Despite such concerns, relatively few tree species are protected by either national or international legislation.

The approach to threatened species management is an important debate that will have to be undertaken at some point. The conservation status of a species is an indicator of the likelihood that it will remain extinct either in the present or the near future. Many factors are taken into account when assessing the conservation status of a species: not simply the number remaining, but the overall increase or decrease in the population over time, breeding success rates, known threats and so on. Many rare species will escape extinction provided current management and tenure of the sites they occur on continues. For rare species that occur in conservation reserves, their future conservation depends largely on maintaining the status quo and ensuring that the ecological processes that provide the conditions suitable for the plant to survive and reproduce are maintained. In contrast, rare species populations that are not secure, particularly those that occur on other tenures such as private land, may be at serious risk and be classified into one of the threat categories (i.e. Vulnerable, Endangered, Critically Endangered) (IUCN 2010).

Their small population size and/or restricted distribution mean that rare species are predisposed to disaster from stochastic events such as fire, disturbance from humans or disease (Kerns & Ager 2007). In contrast, threatened species may have had relatively large populations that naturally occurred over broad areas but have suffered declines in range and/or abundance due to threatening processes (Ryan 2002). Depending on the level of this prior decline and the current trend in the remaining population, the species will be allocated to one of the threatened categories (i.e. Vulnerable, Endangered

and Critically Endangered). Unlike many rare species whose populations may be small but stable, most threatened species undergoing active population decline will move into higher extinction risk categories unless the trend can be halted or reversed (Ryan 2002).

In spite of its abundance in lowland forests in Kalimantan, ironwood may eventually become locally extinct because this single-stemmed tree is killed when cut for construction. Several species of wildlife, including the porcupine (*Hystrix javanica*, *Hystrix brachyura*, *Hystrix crasspinis*), known locally as *landak* or *tetung* use the seeds of the Borneo ironwood as food or, like the orangutan (*Pongo pigmeus*), for sleeping or shelter (see Chapter 4). Villagers value ironwood because its fruit attracts animals that they then hunt. Ironwood is the primary wood for local and traditional building and houses in Kalimantan and a source of income for a large number of people in rural communities. Yet, as with other timber forest products, trade in ironwood products may provide a short-term income-generating alternative for people providing sustainable harvesting levels are respected.

1.9. Borneo ironwood as a cultural keystone species in Kalimantan and Indonesia

1.9.1. Definition and understanding

Cultural keystone species are culturally salient species that shape in a major way the cultural identity of a people (Garibaldi & Turner 2004). Garibaldi (2003) stated that their importance is reflected in the fundamental roles these species play in diet, materials, medicine, and/or spiritual practices. Keystone species may serve a particular culture materially in a host of different ways: as a staple food or a crucial emergency food, in technology, or as an important medicine. Garibaldi and Turner (2004) also added that a cultural keystone species may be featured in narratives or have important ceremonial or spiritual roles. It is also likely to be highly represented in a culture's language and vocabulary. As will be described in greater detail, although the specific role a particular species plays in a culture may vary considerably, its designation as a cultural keystone species lies in its high cultural significance. Just as certain species of plants or animals appear to exhibit a particularly large influence on the ecosystem they inhabit, the same is true in social systems. Recently, others significant species have been denoted as 'keystone', such as the sago palm *Metroxylon sagu* (Garibaldi & Turner 2004) in eastern Indonesia and the mesquite (*Prosopis* spp.) in the American Southwest (Nabhan & Carr 1994). These designations underscore the value of further developing a concept of cultural keystone species that articulates some of the defining characteristics of these organisms (Garibaldi 2003).

Borneo ironwood is an ideal candidate to be a 'cultural keystone' for the people of Borneo. Indeed, it is sometimes known as the 'people's species'. Ironwood is valued by people everywhere in Kalimantan for its extremely important and varied use in technology: it is a prized wood for building foundations, houses, boats and bridge structures (Wahyuni & Gunawan 2000). As previously stated, ironwood has a special physical characteristic, namely, its great strength and extremely durability. One particular variety of ironwood is also very tough, yet flexible, and can be split readily into shingles. These qualities, combined with the tree's abundance on Kalimantan, make it a tree of high cultural significance throughout its range. It is considered a gift from the Creator to the people (Yusliansyah et al. 2004). Perhaps because of its immense role in material technology, ironwood is viewed as a sacred tree. It is treated with special respect through rituals and harvesting practices by indigenous people in Kalimantan. Given the important roles played by the people of Kalimantan in the management of ironwood, it is unsurprising that their vocabulary contains many words related to ironwood (see Appendix 1).

Soulé et al. (2003) suggested that the connection between the concepts of ecological keystone species and cultural keystone species is in the defining influence a species exerts within its respective 'sphere'. Unlike ecological keystones, whose identity hinges on the expected ecological influence of a species relative to its biomass, the main criterion for a cultural keystone species is its key role in defining cultural identity; it may or may not be considered ecologically dominant. In this regard, cultural keystone species are not unlike 'foundation species' which have recently been defined as 'highly interactive species that are often extremely abundant or ecologically dominant' (Soulé et al. 2003). For example, trees, grasses, and large mammals such as bison may be designated as cultural keystones in given situations. Although some of these species may be excluded under the current accepted definition of ecological keystone species, they may fit neatly into the cultural keystone definition of one or more cultural groups. If we extend the concept of 'interaction' to include social or cultural interactions, then the term 'cultural foundation species' may also be in keeping with the definition of 'foundation species' by Soulé et al. (2003).

In previous times, ironwood was used for building longhouses and in particular night rituals for the sick involving an exchange in which a carved ironwood 'exchange soul' (*kelakar*) was traded with a spirit for the patient's captured soul (Gonner 2002; Susiarti 2005). The wood was used for the carved coffins and blowpipes of the Dayak people in Borneo. These coffins were decorated with carvings of buffalo heads, crocodiles, house lizards and snakes. However, the traditional use of ironwood has changed over roughly the past hundred years. Its prominence in Dayak culture is still very high, but many of its uses have diminished notably. The Dayak's alienation from their former land base, because of factors such as tree or cash crop plantations and timber company licences, as well as the creation of parks and protected areas, has further reduced the availability and accessibility of ironwood. Yet, despite all the changes in peoples' ways of life, the Dayak culture is still resilient enough to retain its focus on ironwood.

1.9.2. Main traits, indicators and usefulness

Like ecological keystone species, cultural keystone species are dependent on context, i.e., the same species does not have the same value to all indigenous groups in all areas (Power et al. 1996). Changes in diversity or species composition may push another species toward a keystone role. Therefore, cultural keystone species are fluid and may change based on community needs or the availability of species. The cultural value of a cultural keystone depends on the community's ability to use it for food, material, or technology or in narratives or spiritual practices. Cultural keystone species are expressed along temporal, spatial and social axes, varying from one culture to another and from one region to another. Some keystone species may play key social roles within a restricted time, space or social context, whereas others may be more widely recognised for a longer period and in a broader social context. Cultural keystone species frequently interact with each other, forming a cultural grouping similar to a keystone guild (Power et al. 1996).

According to Power et al. (1996), based on their complex, qualitative nature, cultural keystone species may best be identified using a quantitative index of the following five indicators of cultural influence:

1. Intensity, type, and multiplicity of use;
2. Naming and terminology in a language, including use as a seasonal or phenological indicator;
3. Role in narratives, ceremonies, or symbolism;
4. Persistence and memory of use in relationship to cultural change;
5. Extent to which its role can be replaced or substituted.

Power et al. (1996) also suggested that cultural keystone species may often be grouped into keystone guilds that reflect the collective impact of several species used together at one time of the year or in one location, for example e.g., wapato (*Sagittaria latifolia*), also known as Indian swamp potato, by peoples of British Columbia, water parsnip, coot eggs, and cattail among the Secwepemc. These species may help to highlight land use patterns, traditional ecological knowledge and cultural values. They provide valuable information on the ecological characteristics of an area with considerable historical accuracy that has been passed down from generation to generation.

Researchers have identified four major contributions of the cultural keystone model to conservation and restoration (Garibaldi 2003; Garibaldi & Turner 2004; Platten & Henfrey 2009). Garibaldi and Turner (2004) suggested that by focusing on cultural keystone species, both social and ecological integrity may be enhanced if we want to start our conservation and restoration efforts. They also added that once local people begin to reconnect to their landscape through the conduit of species that have high

importance to them, they will play a much more active role in ecosystem conservation and restoration, including the conservation of ecological keystone species. For anticipating that linking conservation and restoration to cultural concerns will result in an upward spiral of increasing effectiveness in maintaining and restoring both human and ecosystem health.

1.10. A commercially valuable hardwood⁵ species: definition and experiences of hardwood plantation

According to the Merriam-Webster English Dictionary, the definition of ‘valuable’ is either ‘having monetary value; worth a good price’, or ‘having desirable or esteemed characteristics or qualities; of great use or service’. The term ‘valuable’ or ‘high value’ was considered to be too imprecise and open to interpretation (Cooper 1991). The definition of ‘hardwood’ according to Forest Resource Glossary, is trees with broad, flat leaves as opposed to coniferous or needled trees. Wood hardness varies among the hardwood species, and some are actually softer than some softwoods. These trees are also called deciduous trees. Both of definitions of these two words above also supported by Cooper (1991), that has attempted a definition close to ‘valuable hardwoods’ by defining ‘high value end uses’ for these timbers. Cooper (1991) also suggested that valuable hardwoods can therefore be considered as those hardwood species or group of hardwood species with special technical properties (e.g. strength, natural durability and good machining properties) and appearance⁶ (i.e. grain, figure, texture and color or aesthetic qualities) that makes them suitable for “high value end uses”. They are ‘uses ranging from those in which tropical timber (sawn wood, plywood or veneer) is virtually irreplaceable to those uses where it is strongly preferred to alternative materials (wood or non-wood) for technical, aesthetic or commercial reasons’.

These high-grade hardwoods contrast to lesser quality woods used only for wood fuel or pulpwood. The special characteristics of valuable hardwoods lend them particularly well to the speciality markets, which are usually also the highest value markets (Cooper 1991). Ironwood is currently one of the most valuable and important commercial timbers of Indonesia, alongside *ramin* (*Gonystylus spp*), *ebony* (*Diospyros spp* from Sulawesi) and *merbau* (*Intsia spp* from Papua), it is prized for its strength and durability (UNEP-WCMC 2007). Other examples tree species such as teak (*Tectona grandis*), mahogany and rosewood (especially the genus *Dalbergia*) obtain considerably higher prices than commodity timbers. Teak is one of the most valuable multi-purpose tropical hardwood timbers of the world. It is well known for its beauty, strength and

⁵ Hardwoods can be described as the wood of non-coniferous tree species. They can be either deciduous or evergreen. The natural characteristics of most hardwood species make them distinct from softwoods with respect to the finished products derived from the trees.

⁶ The ‘appearance’ of wood used in this sense may be defined as decorative appearance due to its colour, texture and figure, either in isolation or in combination. ‘Figure’ may also be defined as the appearance of the wood due to anatomical features of wood grain, growth rings, rays and knots.

durability, versatility of its applications, dimensional stability under a wide array of environmental conditions, natural resistance to weathering and biological attacks, and its ability to grow well in plantations (Centeno 1996).

In relation to hardwood trees plantations, Keogh (1996) reports that many tropical tree species are difficult to establish in plantations because when planted in pure stands or in open environments, they usually become chlorotic and decline, or they are affected by pests and diseases. Another common explanation for this problem is a failure to recognise the important ecological characteristics of these species. The potential for pest problems may increase going from diverse communities (primary forest) through secondary and regenerating forests to enrichment plantings and monoculture plantations (Cobbinah et al. 1997).

When compared with other commercial trees, the rate of ironwood growth is actually slow (Soerianegara & Lemmens 1994). Ironwood does not seem to be suitable for large-scale plantation establishment as it grows too slowly. The species has never been successfully grown in plantations. So far the species is only planted on a small scale because the supply of seeds and seedlings is inadequate (Asian Regional Workshop 1997). To date, successful plantations and enrichment plantings have been primarily limited to East Kalimantan, where ironwood has been planted by the Forest Department and some timber companies from Kalimantan. Some plantation was carried out in secondary forest in Sumatra (Browne 1955) and plantation continues on a trial basis both in Sumatra and West Kalimantan. In East Kalimantan, planting of ironwood was done by a timber company, namely PT. Kiani Hutani Lestari on a small scale, beginning in 1995. Unfortunately, these plants were burned in 1997/1998 and replanting took place in 1998 (Anonymous 1999). Some obstacles were met, i.e in the stocking of mass seedlings and maintenance in the nursery or in the field.

1.11. Traditional ecological and indigenous knowledge as a basis and a system for adaptive management

During the past decades local and indigenous knowledge has also become central to conservation and development projects, along with a philosophical shift from implementing top-down management to community-based participation (Ellen et al. 2000). Indigenous knowledge is characteristically holistic, integrative, and situated within broader cultural traditions (Ellen et al. 2000). Indigenous peoples in many societies see themselves as a part of the natural world as opposed to detached from nature – as is the case in much of western ideology where man conquers nature. Many indigenous peoples have a respect and knowledge for the environment as their way of life is intermingled with nature. Some scholars now recognise indigenous peoples as shapers of environmental history (Smith & Wishnie 2000). I believe, however, that this does not mean that indigenous people are in constant harmony with nature; there has also been

destruction of forests due to their presence. Evidence of non-conservationist activities have been found at archaeological sites and there is also evidence, based on research by contemporary biologists and ethnographers of anthropogenic faunal extinction and habitat degradation. That said, indigenous societies have maintained lands and resources better than other societies, due to low population densities and with less environmental degradation. Several authors report that indigenous groups have had less impact on the ecosystem than large-scale timber harvesting, mining and migrants from other regions who are not familiar with the ecosystem (Schartzman et al. 2001; Redford & Sanderson 2001). Since the 1980s there has been a radical shift in the thinking about the rights of indigenous peoples and access to natural resources. The acknowledgment that local people have their own effective science and resource use practices are now recognised more than ever before (Sillitoe 1998). Indigenous groups are quite capable and have developed their own methods of conservation and sustainable management practices (Colfer 1997; Gegeo 1998). Indigenous people, conservation organisations and development agencies have come to be perceived as allies in the quest to conserve the last remaining parcels of land that contain great biodiversity (Eghenter 2000a).

Local management by those who are familiar with the ecosystem and have a personal interest in the well-being of the forest appears to be the most effective procedure for conservation and sustainable development in developing countries (Colfer 1997; Furze et al. 1996). Indigenous peoples have a wealth of knowledge on plant usage, function, efficient growth methods and medicinal properties, to name a few. Indigenous knowledge and involvement is crucial to the development of conservation and sustainable forestry related projects. The main issues that need to be addressed are the needs of the local people as far as resources and incentives are concerned. It is in the best interest of local people to conserve their natural resources for future generations. In many cases indigenous groups have put limits on harvesting and hunting through customary laws and have developed reserves to protect their lands from new migrants in the region (Furze et al. 1996).

I conclude that when a voice is given to indigenous peoples and importance is given to the immeasurable knowledge of their lands, there is a sense of pride in being involved in management and conservation projects. Forest dwellers hold a wealth of knowledge about the environment. Conservation agencies have used this knowledge to develop and implement plans for both conservation of biodiversity and the development of economics, social and cultural interests of marginal peoples (Eghenter 2000a).

The conversion and degradation of forests worldwide has led to a dramatic loss of cultural diversity, and with it a corresponding loss of traditional forest-related knowledge (Lovera 2008). The importance of traditional knowledge is explicitly recognised in the CBD (Convention on Biological Diversity) and was further elaborated on in the IFF (Intergovernmental Forum on Forests). The CBD is the designated organisation to follow up on recommendations of the IFF regarding traditional forest based knowledge.

The CBD distinguishes the following features of indigenous knowledge:

- information about the various physical, biological and social components of a particular forested landscape;
- rules for using them without damaging them irreparably;
- relationships among their users;
- technologies for using them to meet the subsistence, health, trade and ritual needs of local people;
- a view of the world that incorporates and makes sense of all the above in the context of a long-term and holistic perspective in decision-making

There has been an insurgence of indigenous knowledge as an applied theoretical approach in relation to socioeconomic methodologies (Crevello 2003). The theory of Cultural Ecology and Neo-Evolutionism ideologies stem from the influence of environment on cultural development. The basic features include the impact of environment on culture, focus on adaptation, and reciprocal links between culture and ecology, as illustrated by indigenous groups who rely on forest resources for survival (Barrett 1996). Indigenous conservationism is now a widely accepted ideology that is culturally expressed in conservation ethics, as well as in natural resources use and animistic religious beliefs. For example, the Mentawai of Siberut Island, Indonesia, who through their traditional religion believe that all elements of the earth have a soul, believe that proper offerings must be given in order to maintain cosmic harmony. Benuaq Dayak shamans rely heavily on spirits from the natural world for healing ceremonies. Aspects of indigenous conservationism have been identified for many indigenous groups who continue to rely heavily on natural resources for subsistence economies (Crevello 2003).

Indigenous participation is used as a process of empowerment to amplify traditionally unacknowledged voices (Slocum et al. 1995). Participation focuses on ways to mobilise local resources, to engage diverse social groups in decision-making and to identify patterns to eliminate poverty (Feldstein & Jiggins 1994; Slocum et al. 1995). Active and meaningful involvement of indigenous people and the researcher or outside agency involved in the processes regarding issues related to land tenure and social-cultural development – and in decisions related to it – creates a partnership of equals while linking ecological and social justice concerns. It is important that researchers or agencies link management practices to social, temporal and environmental circumstances to particular communities where such practices are present (Eghenter 2000b).

1.12. The market chain

The market chain comprises collectors, traders, producers and consumers of ironwood moulding and other forms. This study adopts the definition of a supply chain that has been given by the editors of the *Journal of Chain and Network Science*⁷: 'A supply chain is a network of organizations that are involved through upstream and downstream linkages in different processes and activities that produce value in the form of products and services in the hands of the ultimate user' (Omta et al. 2001).

The companies that are actively involved in the sequential processes and activities that produce a specific product or service are referred to as the 'primary supply chain members' (Omta et al. 2001). On the supply side of the international chain of ironwood products from East Kalimantan there are the ironwood moulding exporters and manufacturers. In contrast, the 'supporting members' of a supply chain are companies that simply provide resources, knowledge, utilities or assets to the primary supply chain members. Here, these include the general suppliers of: wood, sawmills, kiln-dry ovens, machinery, tools, packaging cardboard, etc. Other important supporting supply chain members are freight forwarding and shipping companies, which undertake the transportation from East Kalimantan to foreign export markets. The primary supply chain members who are involved in the same process/activity compose one tier within the supply chain. The total number of tiers across the supply chain is termed the 'vertical structure'. The 'horizontal structure' refers to the number of supply chain members in each tier. The ranking of the tiers is subject to the perspective of the particular company selected to look at the supply chain, the so-called 'focal company'. The 'vertical position' refers to how far or near the focal company is to the initial source of supply and the ultimate customer (Stock & Lambert 2001).

1.13. Direct causes of ironwood depletion

I believe that ironwood in Kalimantan is considered a flagship species by local people. Therefore, when ironwood disappears from the forest it may indicate serious degradation and it is likely to coincide with general species loss. I also think that the decrease and possible extinction of ironwood in some areas is linked to the causes of accelerated forest and land degradation and the loss of biodiversity in tropical rain-forests that is particularly evident in Kalimantan in the form of deforestation by clear-cutting and intensive forest practices (overexploitation of forests), illegal logging, conversion to agriculture, slash and burn agriculture or shifting cultivation, rapid population increase and urbanisation, lack of law enforcement and control, and enhanced large-scale forest fires (Hillegers & de Jongh 2001).

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Based on my literature review, I found that commercial logging has played a leading role in deforestation and forest degradation in Kalimantan. Degradation of forest caused by uncontrolled logging, forest fire and forest conversion to other uses is increasing continuously. Since the 1980s and 1990s, in the context of environmental concerns in Indonesia, deforestation has become a common and prevalent issue and remains very controversial. In this case, deforestation means any form of forest cover reduction and includes all activities resulting in forest depletion, either in vegetation density or in area of coverage. Some human activities result in an entire loss of ironwood habitat, because regeneration of the forest is unlikely or impossible; for instance, in the case of conversion for agriculture or plantation of cash-crops (oil palm, rice, maize, pulp-wood, rubber, coffee, etc) and open-pit mining.

During logging activities, felled trees frequently destroy the seedlings or saplings of various species, including ironwood. As residual stands, ironwood stands suffer from severe damage during logging operations. Extracting only the biggest trees of the most valuable species leads to the destruction of vast areas for the collection of only a small number of exceptionally valuable trees. At the same time, selective cutting not only reduces the number of old trees, but also young trees (seedlings and saplings). Concessionaries have been engaging in inefficient logging practices. The inefficient use of timber resources is reflected in the portion of logs recovered, the amount of wood waste, and the damage done through current logging practices compared with sustainable practices (Barr 2001).

Indonesian forests are some of the world's most rapidly disappearing forests and there is evidence that this loss is accelerating (FAO 2007). Between 1985 and 1997, some 20 million ha of forest were destroyed in Indonesia (about 1.7 million ha per year), most of it lowland forest below 300 meters where more than 60 per cent of all rainforest species occur (World Bank 2001). Between 1990 and 2005, approximately 108,110 mi² of Indonesian forest disappeared, 83,785 mi² of which were virgin forests (Chan 2010) and deforestation increased to 2.8 million ha per year (Indonesia MoF 2004). The steady drop in rainforest cover has been alarming – in the 1960s, 82 per cent of Indonesia was forested, a number which dropped to 68 per cent in 1982, 53 per cent in 1995 and 49 per cent in more recent estimates (Chan 2010). At current rates of deforestation, 98 per cent of Indonesia's lowland forests may be destroyed by 2020 (Nellemann et al. 2007).

In the mid-1980s, Borneo's forests still covered 71 per cent of the island. This percentage dropped to a mere 54 per cent by 2000 (FWI/GFW 2002). In Kalimantan the situation is particularly dire. Whereas in 1985 nearly 40 million ha were still forested (75 per cent of the total land mass), by 2002 this number had dropped to less than 27 million ha, just half of the land mass (Holmes 2004). The World Bank predicts that by 2010 all lowland forests in Kalimantan, outside protected areas, will have disappeared (World Bank 2001; FWI/GFW 2002).

I think that the deforestation scenario in Indonesia, particularly in Kalimantan, reflects overall general trends of degradation, due to various causes, with logging as the most predominant cause. Historically, a major source of deforestation and forest degradation has been the large-scale commercial timber interests. Given that all the lowland forests in Kalimantan contained ironwood stands, such a tremendous loss of forest must also somehow reflect the crude loss of ironwood.

1.14. The underlying causes of ironwood depletion

The causes of ironwood depletion are habitat degradation (timber exploitation), fragmentation and over-exploitation. In the early 1970s, the Indonesian government granted timber concessions to a large number of foreign and national companies. Particularly in Kalimantan and Sumatera, forest management is generally undertaken by *Hak Pengusahaan Hutan* (HPH⁸ or Forest Concession, Forest Exploitation Rights). East Kalimantan forest management has been dominated by industrial timber extraction. This had several detrimental effects on local communities. Jessup and Peluso (1986) noted that in particular, despite local communities' legal right to collect minor forest products within timber concessions, villagers have at times been denied entry to those areas, and timber company personnel have otherwise infringed on the rights of local residents. For instance, there is evidence of company guards confiscating rattan from collectors, of loggers raiding caves and selling stolen birds' nests to unauthorised buyers, and of timber companies illegally cutting Borneo ironwood, a species reserved for local use; such acts sometimes led to violent confrontations between local inhabitants and company guards or loggers (Jessup & Peluso 1986).

In the 1980s, the Ministry of Forestry and the Indonesian state value Kalimantan's forests primarily for their timber (GOI-IIED 1985). About 40 per cent or some 64 million ha, of Indonesian forests are production forests, constituting almost 60 per cent of all production forest in Southeast Asia (World Resources Institute 1988). Some 32 per cent of Indonesia's forests and 40 per cent of the nation's production forest is found in the four provinces of Kalimantan (GOI-IIED 1985). Though the percentage of foreign exchange provided by timber to the Indonesian economy has been declining in the wake of a massive government effort to export non-oil and non-timber commodities, wood products are still the country's most important export after oil and natural gas.

The Environmental Investigation Agency's (EIA) (1997) report entitled *Corporate Power, Corruption and the Destruction of the World's Forests* presented the results of a study on the impact of transnational timber trading corporations. Its major conclusions were:

8 Under the HPH timber concession system, private logging, companies and state-owned enterprises have been able to obtain concession licences to harvest timber in areas designated as production forest and limited production forest for a period of 20 years.

- The global timber trade, dominated by transnational companies (TNCs), plays a central role in the destruction and degradation of the world's diminishing natural forests and the ensuing loss of environmental, social and economic functions. This trade remains outside of any coherent global regulation.
- While forests are national assets, they are of immense international importance, particularly as storehouses of biodiversity and in their role in climate regulation. Similarly, both the causes and effects of forest loss are frequently international in nature and extent.
- Increasing trade liberalisation and the globalisation of trade have led to a shift of power away from national governments to corporate leaders and have undermined the ability of national governments to control and regulate effectively the international timber trade.
- Transnational companies often have the economic and political power to undermine national management of forest resources by gaining unrestricted access to forests.
- Excessive, increasing and unsustainable international demand by the developed world for timber and other forest products (e.g. rattan, agarwood) is having a devastating impact on forest worldwide.

To this last conclusion I can added the following: (1) the worldwide demand for all sorts of industrial cash crops, such as palm oil, corn and cassava, is resulting in thousands of square kilometres of forest being destroyed each year and will apparently continue until all accessible land has been appropriated; and (2) a global policy of international organization to frustrate conservation through euphemistic concepts, such as 'sustainable development' and 'participatory management'.

Construction wood gathering is sometimes seen as the major cause of the depletion of wood resources and deforestation. However, I think this is rarely so; other and more destructive forces are usually at work as well. This is not to say that the need for construction wood is not a potent element contributing to the collapse of traditional wood resource management systems in some areas. Certainly, where wood demand exceeds natural regeneration, over-cutting is the likely outcome. Although Borneo has more than three thousand tree species, only a few are harvested for commercial timber. I found that loggers focus on fewer than a hundred species in Kalimantan, with exports predominantly of twelve species. In Kalimantan the most valuable timber trees are ironwood and dipterocarps, including *meranti* (*Shorea leprosula*, *Shorea macrophylla* and *Shorea albida*), *merawan* (*Hopea spp*), *kapur* (*Dryobalanops spp*), *keruing* (*Dipterocarpus spp*), *ramin* (*Gonystylus bancanus*), *Intsia bijuga*, *Intsia palembanica*, *Pericopsis mooniana*, and *Pterocarpus indicus* (MacKinnon et al. 1996).

Conversion forests by clear-cutting

My literature review also showed that lowland forest and ironwood related forests have been cleared in order to convert land for agricultural purposes (forest conversion). Plantation forests are found throughout Indonesia and natural forest stands are often cleared in order to produce estate crops such as oil palm or banana trees. Highly valued palm oil has influenced the Indonesian government to convert forested land into plantations in many of the outer islands in Indonesia (NRM 2000). Large-scale agricultural expansion of oil palm and banana plantations are being promoted and developed throughout Indonesia, including on large tracts of land in East Kalimantan. Forest conversion for plantations is regulated though a number of licensing requirements authorised by the MoF. This includes the forest clearance licence (IPK) and the industrial timber plantation licence (HTI).

The forestry ministry delegates management of 'production' and 'limited production' forests to private concessions and state-owned enterprises. It designates 'conversion' forests for timber harvests followed by conversion to agricultural and other non-forest uses. Conversion forests may be designated for conversion to estate crops or forest plantations, in which case the authority for their oversight remains within the MoF; or they may be designed for use by transmigrants, in which case the authority will be transferred to the Ministry of Transmigration and Shifting Cultivation once conversion occurs.

I have already concluded that the rate of deforestation in Indonesia between 1985 and 1997 reached 1.7 million hectares per year, while in period between 2000 to 2004, it was 2.8 million hectares per year (Indonesian MoF 2004). This figure includes both production forests and conservation forests and indicates that Indonesia's forests are increasingly being destroyed. Furthermore, forest degradation threatens some species of forest plants with extinction. Threats that have contributed to the damage of forest resources include illegal logging, overexploitation, forest fires and forest conversion for other uses like crops plantation, timber estate and transmigration area.

The Indonesian government has scheduled more than two million hectares of land in East Kalimantan for future vegetation conversion. The purpose is to establish tree crop plantations. In Kalimantan, approximately 8.5 million hectares were lost between 1985 and 1997, half a million hectares of which were converted to smallholder plantations and 1.7 million to large-scale estates (Sawit Watch 2004). Government plans will put further pressure on the already degraded ironwood forest stands and other hard wood species.

Large-scale plantations and industrial forest or timber plantations (HTI)

Timber-tree-crop plantations or industrial plantation forest (IPF or HTI = *Hutan Tanaman Industri*) have grown rapidly since the early 1980s and, have developed in line with the decreasing of wood supply from natural rain forest (Wardojo & Masripatin 2002). The main purpose behind the establishment of IPF was to guarantee the supply of raw materials from the forest product industry, such as construction wood, pulp, rayon and paper, as well as luxury woods. Timber plantation concessions have been promoted by the government, through subsidies and preferential regulations, in anticipation of the growing demand for industrial wood, primarily from the pulp and paper industry. However, because of inappropriate incentives (subsidies, permission to clear-cut logged-over forests, and the unattractiveness of the long-term investment in timber because of low log prices and pervasive illegal logging) natural forests have been degraded, while the area actually planted is much smaller than the area allocated (Gautam et al. 2000). Gautam et al. (2000) added that at the same time, significant investments have been made in pulp and paper industrial capacity, which has significantly increased the demand on natural forests to meet their growing raw material requirements. The growth of tree-crop plantations has also been rapid, particularly oil palm plantations, in response to strong financial incentives, which have increased in the aftermath of the recent economic crisis. These trends have added substantial pressures onto forests.

According to Barr (1999), that the government regulation no.7 of 1990 mentioned that HTI development can take place within production forest, and the permit allows the holder to clear-cut a designated area and to replant it with commercial tree species. The scheme was designed ostensibly to rehabilitate unproductive (or degraded) forests, with a residual standing forest inventory of less than 20m³ per hectare of commercial species with a minimum diameter of 30cm. Kartodihardjo and Supriono (1998) reported that with the changing trends in the processing sector and emerging market forces, the rent-seeking has increasingly turned toward exploiting the HTI system, often in combination with the HPH system, and the conversion of natural forests to estate crop plantations. The sector is plagued by governance problems, which have made the official forest policy de facto ineffective. This is well demonstrated by the events following the 1997/98 forest fires. Of the 176 companies found responsible for starting the fires to clear land for plantations, including 133 oil palm companies, virtually no action has been taken against any company. Ironically, the timber plantation concession system is leading to the degradation of forest areas rather than their regeneration, while unclear and overlapping forest boundaries have resulted in granting concessions and conversion rights in areas meant to be protected and conserved.

According to the Indonesian Forestry Community (1998) there are about 22.1 million hectares of former forest areas that are not being forested. These non-forested areas need to be rehabilitated or reforested in order to become productive again. In this case, natural and man-made regeneration may be applied. In several cases, the

government of Indonesia has converted the degraded forests into concessions for the industrial forest plantation permit (HPHTI or *Hak Pengusahaan Hutan Tanaman Industri*). The types and total of HPHTI areas are as follows: (1) 0.7 million ha for transmigration purposes; (2) 2.9 million ha for pulp production; and (3) 1.8 million ha for wood production (Febrianto & Hadi 1999).

I suggest that tree crops such as rubber, oil palm, cocoa, coffee, and coconuts are important commodities with growing international markets. Malaysia and Indonesia are the main suppliers of palm oil and rubber and have converted thousands of hectares of natural forest into plantations. In both countries, oil palm estates have expanded rapidly in recent years and represent a major cause of deforestation (Potter & Lee 1998). In addition, Indonesia currently has the largest areas of oil palm plantation in the world, with a total area of oil palm plantation of 5.5 million hectares (Sawit Watch 2004).

An important conclusion to be drawn from my literature review is that most plantations are currently in Sumatra and Kalimantan and are being rapidly developed (particularly those in West Kalimantan). Papua (Irian Jaya) is the primary target for future expansion (Triwibowo & Haryanto 2001). According to Kartodihardjo & Supriono (2000) that it can be said that almost all of the existing oil palm plantation areas result from the conversion of production forest. This is because the procedure for acquiring forest land is relatively easy, and the firm can clear-cut and sell standing timber, a profitable side-business. By 1997, the agreed area of production forest to be converted for plantations had reached 6.7 million ha – in addition to the nine million ha proposed for further tree crop plantation development on other lands (Sawit Watch 2004).

The transmigration scheme

Large-scale land conversion is used for the development of plantations (primarily oil palm and timber) as well as for the country's transmigration programme. I conclude that agricultural and forest plantation expansion has contributed to the conversion of naturally forested land to other uses. The resettlement of the outer islands was promoted primarily through a transmigration programme. There have been transmigration programmes in Indonesia since the early 1900s, peaking during the New Order regime of 1965 to 1998 (Sunderlin & Resosudarmo 1997). Since 1999, there has been little expansion of transmigration activities. Government sponsored transmigration programmes in Indonesia relocate people to remote outer islands in order to resettle landless people from Java and to develop remote regions. However, problems arise when the land allocated for these projects has already been claimed by indigenous people. New residents to these areas are not familiar with the ecosystems and often farm using methods that are not sustainable and lead to deforestation.

The resettlement project which encompassed plantation development, gave rise to the creation of the transmigration (or social plantation) scheme in 1992, following a joint decree between the Indonesian MoF and the Ministry of Transmigration (Hartono 2002). This decree compelled a hundred logging concession holders to develop timber and pulp plantations under the transmigration program. The Government provides a modest house, a 0.25 hectare parcel of land as a home garden, and rice (for a period of one year) to all transmigrants. According Hartono (2002) that transmigrants do not own rights to any part of the plantation land; thus, working on the plantations is their main source of income. Hartono (2002) noted that the companies in the transmigration scheme have obtained land allocations of between 6,100 to 29,700 hectares, the average allocation being about 11,500 hectares. A number of firms participating in the transmigration scheme receive financial support from the government. Those that do not receive financial assistance are classified under the self-financed category.

Transmigration settlements are typically cleared from forested area and provide areas for homes as well as an average of two hectares of agriculture land per family. Clearing for transmigration sites results in the loss of biodiversity and forest resources. The success of a transmigration site rests on the care taken when land clearing. Often, land clearing results in significant loss of top soil, which, in turn thus results in low agriculture productivity for transmigrant farmers. This often leads to encroachment into nearby forest land and then subsequent loss of, additional forest and biodiversity (MacKinnon 1996).

I conclude from my literature review that logging, agricultural expansion and economic development policy are identified as the direct causes of ironwood depletion and deforestation in general. The combination of these factors presents a serious threat to the biological diversity of the forest. In fact, over one fifth of total acreage depletion in East Kalimantan is being used explicitly for the production of modern ironwood products. Ironwood is a valuable tree species associated with old-growth forests and a slowly generating tree species that is found in mixed dipterocarp forests. When the dominating harvesting method is clear-cutting, this leads to the fragmentation of mature stands. If clear-cutting continues there will be devastating and long-term consequences for the forests of East Kalimantan. The ironwood tree, which is the hardest wood in the world, is being cut as a side effect of forest clearing, although it is not the only species being removed from forests. Many other trees, plants and animals critical to the stability of the tropical forest eco-system are also being destroyed in the process. Endangered wildlife species, such as the orangutan (*Pongo pygmeus*) are also present in lowland tropical forests. Although Dipterocarpaceae trees are considered a resilient plant, they will nonetheless take 50 to 100 years to grow back. The ironwood is one of the most ancient living organisms, with a life span of 1,200 years or more; however, it has an extremely low regeneration rate, which is difficult to pinpoint.

Over 500,000 acres of lowland forest have been cleared in eastern parts of Kalimantan in order to meet the growing demand. As mentioned, the removal of ironwood from any

given area has the potential to destroy all plant diversity. It is estimated that regeneration of these areas will take at least 500 years because of their immense dependence on ironwood. In fact, in those places where large numbers of ironwood trees have been removed, the collapse of the ecosystem is already occurring – virtually all plant and animal life has disappeared and citizens must now travel between 30 and 50 miles to obtain the wood. In short, a decrease in ironwood will result in lower levels of diversity, abundance and species.

This thesis

Following the introduction of the thesis in this first chapter, which covers an extensive literature review on Borneo ironwood, the remaining chapters will be presented as follows:

- Chapter 2 provides a description of the research area and methods
- Chapter 3 provides an inventory of the natural distribution of ironwood and tree diversity in association with the variability of ironwood at the research sites
- Chapter 4 covers a study of a traditional forest management system and sustainable utilisation strategies for ironwood in East Kalimantan.
- Chapter 5 is a case study of a well-functioning local traditional forest management system, which demonstrates the performance and potential for forest management and a study of silvicultural and conservation efforts for ironwood by indigenous peoples
- Chapter 6 provides an analysis of ironwood raw material sources as external factors that contribute to forest degradation and depletion of ironwood trees in natural forest. It also examines ironwood products both the production and the consumption chain and offers an analysis of available ironwood trade documentation
- Chapter 7 provides a synthesis that offers overall discussion and concludes how the findings relate to the traditional management of ironwood, important insights into and addresses recent issues in this area. In addition, it formulates recommendations for a set of integrated policies in relation to the exploitation of forest timber, to support the sustainable management of ironwood and its cultural role in the life of local people in the research areas.