BIODIVERSITY AND SUSTAINABILITY IN THE BULUNGAN RESEARCH FOREST, EAST KALIMANTAN, INDONESIA: THE RESPONSE OF PLANT SPECIES TO LOGGING

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DECLARATION

I hereby declare that all the work in this thesis was composed by myself, except where specific acknowledgements are made.

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ABSTRACT

This study reports forest structure, regeneration and the soil properties from unlogged and logged forest in the Bulungan Research Forest, Malinau District, East Kalimantan, Indonesia. Four sites were compared by using four 1-ha replicate plots in each of primary forest (PF), 5, 10 and 30-yr old logged forest (LF-5, LF-10, LF-30).

The tree species composition differ among forest types, as it was shown that the mean value of similarity indices for all pairs were 0.215 (for the Jaccard index) and 0.353 (for the Sorensen index). The low values for similarities among forest types were most probably caused by low numbers of species shared between each forest type. Both correlation values, r = 0.023 for Jaccard index and r = 0.031 for Sorensen index, showed no strong correlation between the similarity index (C) and the distance between forest types. This supports the use of a chronosequence approach.

A total of 914 tree species with ≥ 10 cm dbh were recorded from 223 genera and 65 families. There were no significant differences in mean species numbers (166 – 180/ha) among treatments. Mean density of species was lower in LF-5 and LF-10 (501/ha) than in PF or LF-30 (605/ha and 577/ha); similarly to mean basal area (LF-5, 28.5 m^2/ha; LF-10, 32.6 m^2/ha) vs. PF (45.8 m^2/ha) and LF-30 (46.9 m^2/ha). Dead wood on the forest floor was significantly higher in LF-10 (75 m^3/ha) than in the other treatments.

Seedlings (< 2 cm dbh) of 1,022 species were recorded from 408 genera and 111 families. The mean number of tree seedling species ranged between 170-206; the mean density of seedlings was about two-fold lower in LF-10 (2790/ha) than in the other treatments. Saplings (>2 – 9.9 cm dbh) of 802 species belonged to 241 genera and 65 families. There was a high variability in species richness across treatments (89 – 191/ha), but not in stem numbers. The Dipterocarpaceae family was dominant in all treatments, followed by the Euphorbiaceae.

The soils were acidic, low in nutrients and had low to very low fertility. Both primary and logged forest areas are marginal or not suitable for sustained production of plantation crops. Logging caused soil compaction in LF-30.

Although in terms of number of species and trees, amount of BA, number of saplings and seedlings LF-30 appeared to have satisfied prescriptions for a second harvest, ecologically the forest is far from mature.

The Indonesian Selective Cutting and Replanting (TPTI) system may need to be revised to a 35 – 45 year cycle to ensure long-term forest productivity in terms of not only timber but other goods and ecosystem services, the value of which are never quantified in monetary terms, but can be higher than the timber revenue.

Keywords: logging, primary forest, logged forest, species, genera, family, bulk density, soil nutrients

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CHAPTER 1. GENERAL INTRODUCTION

Tropical Rain Forests of Indonesia

Tropical rain forest is one of the richest ecosystems (Whitmore 1990). It occurs in three main areas, namely South and Central America, Central and Western Africa and the Indo Malay-Borneo-New Guinea regions (Richards 1952; Odum 1971; Whitmore 1990). The Malay archipelago or Malesia is the second largest, with Indonesia occupying most of the area (Whitmore 1990), covering 60% of all forested lands in Southeast Asia and known as the third largest tropical forested area in the world after Brazil and Zaire.

Indonesia is also known as the Sundaland hotspot (Whitten *et al*. 2004). It covers the western half of the Indo-Malayan archipelago, an area of about 1.5 million km^2, lying on the equator and spanning a distance of 5,000 km between the Asian mainland and Australia. This area is dominated by Kalimantan (725,500 km^2) and Sumatra (427,300 km^2), the third and sixth largest islands on earth. Two-thirds of Indonesia's land area of 191 million ha is forested, mostly with tropical hardwoods, and the rest is covered by shrubs, ferns and herbs that describe this ecologically complex system (Choong & Smith 1994).

The wide range of geographical and climate conditions of Indonesia have resulted in one of the richest flora and fauna in the world. More or less 25,000 species of vascular plants can be found in the forest. It includes 381 species of mammals, 449 species of reptiles, 242 species of amphibians and 1,000 fresh water fish species. Kalimantan is home to about 430 fish species, with 164 of them endemic, while Sumatra has 270 species, 42 endemic (Kottelat & Whitten, 1996 *in* Whitten *et al*. 2004). The above source also reported that Indonesia has a variety of endemic species such as 173 mammals (27 in Kalimantan), 146 birds (30 in Kalimantan), 249 reptiles, 172 amphibians and not less than 15,000 species of vascular plants. Kalimantan leads in endemic plant genera with 59 and Sumatra has 17. Kalimantan also has over 2,000 species of orchids. The flora includes several spectacular taxa, such as *Rafflesia*, famous botanical flagship for tropical rain forests, especially *R. arnoldi*, which has one metre “petals” and is the largest flower in the world.

Soerianegara & Lemmens (1994) reported that among 4,000 recorded Indonesian timber species, consist of 400 species of important timber; 260 species of commercial timber and 120 species of major commercial timber (Martawidjaya *et al* 1986 *in* Manan 1993). Kalimantan has some 3,000 species of trees, including 267 species of Dipterocarpaceae of which 155 (58%) are endemic to the island and many are economically important (Whitten *et al*. 2004).

Global issues on biodiversity decline have for long focused on production forests as after opening up the forest for logging often land conversion, planned or spontaneous, occurs to other land use forms. In Indonesia, lowland forest is believed to be the richest biodiversity area, however, due to the government interest in economic development most of it is allocated as production forest. According to Kartawinata *et al*. (2001), estimates of the extent of forest cover in Indonesia vary widely depending on the information sources. The Minister of State for Population and Environment of Indonesia (MOSPE) in 1992, using data from the Regional Physical Planning Programme for Transmigration (RePPProt 1990) and Dick (1991), gave an estimation of 118 million ha, excluding Java, Bali and the Lesser Sunda Islands. The Indonesian National Forest Inventory, utilizing 1986-1991 satellite data, recorded that the total forested land covered 120.6 million ha or 69% of the total land area, excluding Java (GOI-FAO 1996 *in* Kartawinata *et al*. 2001). The Forest Land Use Allocation by consensus and the Provincial Spatial Plan harmonised their data up to April 1999 and estimated the area of about 121.1 million ha (Santoso 1999; Ismail 2000 *in* Kartawinata *et al*. 2001). LANDSAT data indicated that the forest area is 99.24 million ha, or 25% less than government statistics would suggest (Santoso 1999 *in* Kartawinata *et al*. 2001). However, the government recently claimed that the total forest area is 120.4 million ha (MOF 2005) and of this amount of forest 109.9 million ha has been classified into five major utilization classes (Table 1).

Table 1. Forest area in Indonesia according to government classification

Forest Land Class	**Area (M ha)**
Conservation forest	23.2
Protection forest	29.1
Production forest	27.7
Limited Production forest	16.2
Converted Production forest	13.7
Total	109.9

Source: MOF 2005

These richest biological regions are now at critical levels due to the pressure of human activities, land use or resource management and this will deplete species diversity (Samsoedin & Mogea, 1989).

Logging Activities in Indonesia

The History of Logging

Timber exploitation has a long history in Kalimantan and was already important during Dutch colonial times (MacKinnon *et al*. 1990). Sewandono (1937 *in* Smits 1994) reported that there were Chinese wood exploitation companies which settled on islands near the coast of Sumatra and on Sumatra itself, not far from Singapore, starting their activities around 1880. Most of the forests logged were in peat swamps, with an average 70 m^3/ha of marketable wood. The felled trees consisted of Dipterocarpaceae, Apocynaceae, Annonaceae and other families. The trees were felled manually and transported on round wood roads, covered with mud or pig fat to reduce friction. The same system was used in Kalimantan where it was called "kuda-kuda" logging. The wood was transported by ship to Singapore.

In 1904 a number of timber concessions were granted in the upper Barito, Central Kalimantan and East Kalimantan especially Kutai (Potter 1988 *in* MacKinnon *et al*. 1990). By 1914 80% of timber floating down the Barito was from dipterocarps, while wood coming from the east coast was mainly ironwood (*Eusideroxylon zwageri*) (van Braam 1914 *in* MacKinnon *et al*. 1990). The large eastern tracts of dipterocarps were much more inaccessible and difficult to exploit, and several early attempts failed, in spite of heavy investment (Potter 1988 *in* MacKinnon *et al*. 1990).

In 1924 Dutch colonial officers produced a forestry map for Central, South and East Kalimantan, which showed a forest cover of 94% in these areas. Figures for the extent of forested land published in 1929 were still the basis of giving timber concessions in 1975 (Hamzah 1978; Potter 1988 *in* MacKinnon *et al*. 1990). Around

1925, the Forest Service started a systematic exploration. Surveys were made of the standing volume using a line sampling method. Numerous herbarium specimens and wood samples were collected and identified and the Forest Research Institute prepared a list of scientific and local names of the trees (Hildebrand 1949-1954 *in* Smits 1994).

In 1933, some Japanese companies started buying logs, especially the lighter *Shorea* species, near Tarakan, East Kalimantan. They bought the wood from local Dayaks and shipped it to Japan. The Dutch government made the companies work under The Nango Ringijo Kaisha (South Pacific Forest Exploitation Company) and gave them a forest concession near Sangkulirang Bay. A large amount of commercial wood especially Dipterocarpaceae could be harvested from this forest (Smits 1994). By the end of 1940, the company had established a fairly profitable enterprise employing 1,000 Indonesian and 100 Japanese labourers. About 100,000 m^3 of logs were transported by railway to the log pond, from where they were shipped to Japan. An indigenous method with small dams to float logs through rivers was also used. In this concession a tractor was also tested, as well as high-lead logging with the use of light equipment. Because of the war the activities were stopped. In East Kalimantan near Nunukan and Sebatik a large concession called “Oost Borneo” was granted to Dutch companies i.e. KPM (Koninklijke Pakketvaart Maatschappij), NISHM (Nederlandsch Indische Steenkolen en Hout Maatschappy) and the local government of Bulungan as shareholders. Owing to the great financial losses the Dutch Government stopped this operation in 1941 (Kools 1949 *in* Smits 1994). During that period other important wood companies in East Kalimantan were the Borneo Busan Kaisha, in Samarinda, the firm H. Yukimoto in Balikpapan, and BPM (Bataviasche

Petrolum Maatschappiy), an oil company (Boer 1973 *in* Smits 1994). The latter felled large quantities of wood, mainly for its own supply. These companies and several other smaller ones obtained wood from their concessions through intermediary Chinese traders, not through organized logging activities of their own. The plan for exploitation of the Batu Licin forest in South Kalimantan for the abundant Dipterocarpaceae and iron wood could not be carried out because of the World War II. However, a great demand for wood during this war caused the installation of many mechanical sawmills such as those in Balikpapan, Samarinda and Nunukan in East Kalimantan. After the war these sawmills were taken over by the Forest Service.

In 1958, Soepomo and Ardiwinata (*in* Smits 1994) pioneered experiments on mechanical logging in Mentawai near Balikpapan, East Kalimantan. Here the rail system was used to transport the logs to a log pond. Modern logging operations usually build road systems to enable them to do year round logging and transportation of the logs under all weather conditions. The approval of the law on forest investment in 1967 made logging operations very profitable. The exploitation was no longer limited to exiguous zones along the river banks, since heavy equipment could be used. After the law of foreign investment came into force, large-scale exploitation of the forest started which led to the timber boom of the 1970s (Manning 1971 *in* Smits 1994).

Up to the late 1970s, Indonesia's natural forests were in relatively good condition. However, the 1970s was the era when the forest logging activities were started because the government needed a source of income for the development of the country which was known as REPELITA (*Rencana Pembangunan Lima Tahun* or Five Year Development Plans). At that time, the government could not depend on oil where the price and limits to production were dictated by the OPEC, of which Indonesia is a member. Therefore, forests tended to replace oil as the major source of government income.

The Development of Forest Regulation in Indonesia

During the Dutch colonization period in 1895, the first forestry law (*Bos Reglement I*) was issued in recognition that serious forest degradation had occurred since the application of *Cultuur Stelsel* (forced cultivation practice of specific commercial crop plants) in 1830. This was followed in 1874 by *Bos Reglement II* which differentiated between teak forest and mixed forests containing many different species. In accordance with the policy of preserving protection forest, especially in West Java, *Bos Reglement III* was issued in 1897, and then further improvements were made as contained in *Bos Reglement IV* in 1913. Finally, in 1927 *Bos Ordonnantie* (Forestry Basic Regulation) was enacted, and complemented by *Bos Verordening* in 1932, with the primary aim of preserving forest for the sake of hydrology as well as socio-economic benefits (Samsoedin & Gintings 1997).

When Indonesia gained independence in 1945, colonial regulations were still used to ensure the maintenance of forest and to avoid the lack of forest regulations. In 1945, the constitution was established and a clear statement in article 33 states that: '*Land, water, and all kinds of national resources are controlled by the state and to be utilized for the maximum prosperity of the people*'. In the new era (1966), before the introduction of enterprises (foreign or domestic) in forestry development, a Foresters Oath was declared in Kaliurang, Yogyakarta. This oath is considered as the basic philosophy of Indonesian foresters. It was entitled ‘The Ideal Foundation for Foresters in Implementing Forestry’, and emphasized that forest utilization must be both optimal and sustainable. In 1967, Basic Forestry Law came into force. Among others, it states (article 6) that the government will initiate an overall plan in all regions to establish the provision, supply and utilization of the forest in a multi-purpose and sustainable way (Samsoedin & Gintings 1997).

To understand the legislation and policies affecting Indonesia’s forests it is important to identify the processes involved in the formation of logged forests. Article 33 of the 1945 Indonesian Constitution stipulates that the State controls forests and the utilization of the resources therein (Kartawinata *et al*. 2001). Commanded by this authority, the government of Indonesia controls, manages and administer the nation’s forest under the provisions of the 1967 Basic Forestry Law (Act 5) and the supporting rules and regulations. In 1999, a new Basic Forestry Law No. 41/1999 was enacted, which helps to strengthen forest conservation measures. Although they were recognized in the 1960 Agrarian Law, customary land rights (*hak tanah adat*) were not clearly acknowledged in the 1967 Basic Forestry Law. However, they were given more emphasis in the new Basic Forestry Law of 1999 (Kartawinata *et al*. 2001).

In the period during the 1970s to 1990s, the government granted concessions to numerous logging companies, however, it failed to adequately enforce harvesting and replanting regulations. The logging companies have focused on maximizing their profits, while the government, benefiting from tax revenues, was responsible for reinvesting some of the revenues to assure adequate forest regeneration, watershed protection, provision of environmental services, and sustainability of traditional social values in the concession. Since 1995, however, the government has empowered local people to take part in forest management and the establishment of social forestry programmes. This was supported by a decree in 1998 that authorized communities to undertake timber harvesting through cooperatives. Another similar programme is the Management of Forest Production by Traditional Societies, which involves non-government organizations (NGOs) working in partnership with local communities (Kartawinata *et al*. 2001).

In 1989 and 1993, the Ministry of Forestry issued decrees stressing tighter control of logging, including pre-harvesting and post-harvesting inventories, diameter limits and post-harvesting treatments to ensure adequate regeneration. However, improvements were negligible, regeneration was poor, growing stocks decreased and environmental degradation continued (DFID & MOFEC 2000). Log production declined to about 25 million m^3 in 1999 (Bureau of Planning 1999). The number of concessions and the area of concessions also declined from 538 in 1987 (Anonymous 1988) to 437 in 1998 (Djamaludin 1998) and 389 in 1999 (Kartidohardjo & Supriono 1999). The decrease in the number of concessions in 1998 and 1999 resulted from the revoking of the licenses of the non-performing concession holders and expired logging rights.

In 2000, the number of the concessions in Indonesia was 270 within the total production forest area allocated for timber harvest of 28.15 million ha: in Sumatra 43 units (2.80 million ha), Kalimantan 127 units (10.76 million ha), Sulawesi 25 units (1.89 million ha), Maluku 24 units (1.84 million ha), West Nusa Tenggara 1 unit (0.03 million ha) and Papua 50 units (10.75 million ha) (Badan Planologi Kehutanan 2002 *in* Mukhtar 2005).

Illegal logging

The impacts of deforestation, which is often initiated by logging, legal or illegal, on biodiversity became one of the most serious conservation concerns in Indonesia. Illegal logging is a major contributing factor to forest disturbance in Indonesia. The legal definition of illegal encompasses the practicing of illegal logging, processing, or trading (Mukhtar 2005). The scope of illegal exploitation encompasses:

(1) Logging wholly or in part carried out by institutions or private entitities to whom it is not legitimised by an authorized institution; (2) Activities wholly or in part carried out by an institution or private entity outside the specifications he had gained permission for for lawfully operate in state-own forest. For example logging trees under an allowable diameter limit, logging trees of protected species, and logging over the permitted volume.

Based on logging and conversion data since 1996, Mukhtar (2005) reported that deforestation in Indonesia reached 2 million ha/year. However, other sources put the rate of forest loss at nearly 3.6 million ha/year in 2002, or a quarter of the total global forest loss.

Forest degradation in Indonesia has been caused by legal and illegal logging, the latter being the major cause of forest destruction. According WWF-World Bank reports 78% of timber trading came from illegal logging (Greenpeace 2003 *in* Mukhtar 2005).

Law and Regulations Related to Illegal Logging has been declared by the Government. There are: (1) Act No. 41/1999 regarding New Basic Forestry Law; (2) Act No.5/1990 regarding Natural Resource and its Ecosystem Conservation; (3) Act No. 23/1997 regarding Environmental Management; (4) Government regulation No.

28/1985 regarding Forest Protection; (5) Government regulation No. 34/2002 regarding Forest Land Use and Forest Planning, Forest Utilization and Forested Area Allocation; (6) Presidential instruction No. 5/2001 regarding the fight against illegal logging and illegal trade in the Leuser Ecosystem Area and in the Tanjung Putting National Park.

Illegal logging organizations are quite similar to a "mafia" where each component has its own responsibilities that support each other. Production forest has suffered from illegal logging conducted by concessionaires or other agents. Conservation forest has also experienced illegal logging including protection forest, experimental forest, and national parks (Mukhtar 2005).

Some technical factors that stimulate illegal logging practices are: accessibility to forest areas, imbalance in the supply–demand mechanism where supply from production forest is lower than the demand from the timber industry, labour availability, lack of a land border system, no post concession management, lack of personnel and forest patrols.

Non-technical factors stimulating illegal logging are: unstable political situation; policy inconsistency; collusion, corruption and nepotism; revenue orientation of local government; euphoria of reformation and lack of law enforcement.

Efforts have been made by the government such as the establishment of a task force in the field. There is also no follow up on various cases tackled during the operation against illegal logging. From 1,031 cases on the operation by the Ministry of Forestry in 2001, not even a single case was brought to court (ICEL-Indonesian Center for Environmental Law 2004). On a television program called "Halo Polisi

Plus" on the "Indosiar" channel conducted in July 2004, the Head of Information Division, Ministry of Forestry stated that combating a illegal logging became more difficult as the stakeholders themselves tended to be involved in the chain. Moreover, a high demand for the cheap timber that comes from illegal logging also makes the situation worse. For example, after the anti illegal logging operation, several local development projects stopped operating as material costs needed to be revised. Illegal logging has been one of the major concerns and priority policies of the Indonesian government.

ICEL (2003) reported information that was released by the Ministry of Forestry through a press conference on January 15, 2003. It gave the picture of the actual condition in the field of tropical forest degradation and illegal logging, as follows: (a) Timber smuggling from Papua, East Borneo, West Borneo, Central Borneo, Central Sulawesi, Riau Sumatra, Nangroe Aceh Darusalam, North Sumatra and Jambi Sumatra to Malaysia, China, Vietnam, India reached 10 million m^3/year. Papua alone contributed to 600,000 m^3/month with a total loss of about Rp 600 billlion/month or about USD 60 million/month; (b) Illegal trading in the North Coastal Area reached 500,000 m^3/month equivalent to 500-700 ships of timber with the total financial loss amounted to Rp 450 billlion/month or about USD 45 million/month; (c) Tremendous forest degradation occurred at the border between Indonesia and Malaysia. In East Borneo degradation reached 150,000 ha/year and in West Borneo 250,000 ha/year.

The Impact of Logging

The response of vegetation to logging

In harvested forests, gaps are generally larger than in primary forest, with soils compacted and churned up by heavy machinery. Thus, advanced regeneration is often destroyed. In such cases, pioneer vegetation germinating from seed dominates initial regrowth (Denslow *et al.* 1990; Pelissier *et al.* 1998; Silva *et al.* 1996; Swaine & Hall 1983). The large canopy openings, initially in the form of generally bare areas, can cover up to 14% to 50% of the ground, and are invaded by light-demanding, fast growing and light-wood pioneer species of little commercial value (Fox 1969, Meijer 1970, Tinal & Palinewen 1978, Abdulhadi *et al.* 1981 *in* Kartawinata *et al.* 2001). Canopy gap dynamics has largely dominated the discussions about rainforest dynamics (Brokaw 1987; Brandani *et al.* 1988; Campbell 1991; Denslow 1987; Whitmore 1997; Whitmore & Brown 1996). In most circumstances, natural gaps have little decisive influence over the overall composition and richness of natural forests at the large-scale (Brown & Jennings 1998; Hubbell *et al.* 1999). These gaps, which are generally relatively small and quickly closed by advanced regeneration, are important for species that thrive on disturbance. For example, non-pioneer-light demanders are species that grow under the shade, but need increased light to reach the canopy include most dipterocarps (Hawthorne *et al.* 1998). Experimental evidence has shown this for some dipterocarp species which better in gaps than in the shade of young secondary forest species (Nguyen-The *et al.* 1998). It has also been shown that seedlings of timber species like *Shorea leprosula* and *Dryobalanops lanceolata* grew faster in logged forests of different ages than in primary forests (Howlett & Davidson 1996, Oorschot *et al.*

1996 *in* Kartawinata *et al.* 2001). Shade-bearers, on the other hand, generally decline when gaps are opened up e.g. *Eusideroxylon zwageri*, which grows without additional light in a closed forest, or for example, as has been shown experimentally for various *Dipterocarpus* spp. and *Agathis damara* (Oorschot *et al.* 1996 *in* Kartawinata *et al.* 2001).

Excessive canopy opening could lead to regeneration problems, especially in exposed conditions where soils dry out rapidly and nutrients are lost through run-off. Herbaceous or shrubby vegetation associated with severe opening could interfere with regeneration and impede forest recovery (Epp 1987; Hawthorne 1993, 1994 *in* Kartawinata *et al*. 2001).

As the canopy gaps resulting from logging are much larger than most natural tree-fall gaps in primary forests, the micro-climatic changes in the gaps are more drastic and can stress organisms adapted to the less severe regime of natural disturbances. Changes in light, humidity, temperature and wind could influence the growth of residual trees, saplings and seedlings (Whitmore & Wong 1958, Soekotjo and Thojib 1978 *in* Kartawinata *et al.* 2001). A high rate of evapo-transpiration leads to soil desiccation, which might in turn prevent seed germination and result in the death of existing seedlings. Crown dieback, sun-scalding of trunks and branches, water stress and insect attacks might also occur, leading to the death of residual trees (Blanche 1978, Ewel & Conde 1980 *in* Kartawinata *et al.* 2001).

Brearley *et al*. (2004) reported that although the basal area, tree height and biomass of old secondary forest approached the primary forest, there were still major diffrences in the floristic and species diversity. Furthermore, in the stands with the lowest remaining basal area, the establishment and growth of dipterocarp was strongly limited by the strong regeneration of pioneer species (Sist, *et al.* 2002).

Succession in lowland dipterocarp rain forest may therefore depend on the successional state of the primary forest when it is logged. Logging not only disturb the forest stucture like any other extreme stochastic event, but interferes with the natural succesion (Bischoff *et al*. 2005).

The Response of Wildlife to Logging

Exploitation of natural forests modifies the ecosystem, resulting in some changes in the wildlife. However, management choices and operational practices can greatly influence the nature and degree of these changes. Since most tropical forests are considered poorly managed, not just for biodiversity conservation but also for productive exploitation (Putz *et al*. 2000, 2001a), there is much room for improvement (Johns 1997; Sheil & van Heist 2000).

"It is difficult to determine exactly how logging affects wildlife. The impacts depend on the species, site conditions and other variables, but declining population is the most noticeable change" (Meijaard *et al*. 2005). Declines are often due to: (a) overcrowding in a limited remaining habitat; (b) decrease in food supply; (c) loss of key microhabitats, and changes in microclimate and microhabitat; (d) juvenile and adult mortalities due to increased predation, hunting, competition, or forage loss; (e) increased juvenile mortality through higher predation levels; (f) more open, disturbed habitats favouring introduced and native predators; (g) invasive species spreading and sharpening the competition for reduced resources; (h) reductions in critical resources, such as food, shelter, courtship and nesting sites; (i) increased morbidity due to new diseases and declining population health; (j) increased hunting pressure; and (k) tree felling, skidding, and other timber extraction activities directly killing or fatally injuring individual animals. In reality, many changes in diversity and abundance occur simultaneously. The changes can then affect other species or aspects of the whole biological community. Ecological studies usually allow us to separate the possibilities, identify the mechanisms responsible for adverse effects of logging, and determine how these vary by site, taxon, and form of intervention (Meijaard *et al*. 2005).

Several studies reported that effects from logging could extend considerable distances into surrounding undisturbed forests over the long-term (Bierregaard *et al.* 2001). The effects created specific microclimates that in turn affected wildlife species via declines in seed production, flowering and fruiting (Laurance 2001; Rankin-De Merona & Hutchings 2001).

The transformation of primary or secondary forests seriously affects some bird species that require a large area of relatively undisturbed forest to maintain their breeding populations or mature trees for their nesting (Mclure 1968, Medway & Wells 1971 *in* Kartawinata *et al.* 2001). However, colonizing birds prefer to feed in disturbed forest and their numbers increased in secondary forest (Johns 1985). Price (1980) reported that insects were severely affected by the nature and intensity of logging, since they tended to occupy more specific environments. Even a single tree provides insects with a large number of distinct habitats. Certain groups of insects have a close and interdependent relationship with certain tree species, hence the removal of the insects or the tree species impinges on the life of the others (Ashton 1989 *in* Kartawinata *et al.* 2001).

Selective logging has negative impacts on the populations of arboreal mammals, because it alters their habitat and decreases food supply (Kartawinata *et al.* 2001). Although to some extent, the situation for browsing animals may be improved by the luxuriant secondary forest regeneration (Whitmore 1984), many of the mammals in Indonesia are in a critical situation. The examples are the two species of orang utan *Pongo abelii* in Sumatra and *P. pygmaeus* in Kalimantan, which are known globally as flagship species, both seriously threatened by habitat loss and hunting (Whitten *et al.* 2004).

The Response of Soils to Logging

Skidding, hauling and yarding of logs can disturb the ground surface by as much as 30% of the logged area (Fox 1969, Abdulhadi *et al.* 1981). The amount of disturbance to soil is determined by the logging intensity and technique, including the size and number of the machines used, and is influenced by the nature of soils and the topography. Along compacted roads and skid trails, water infiltration is reduced (Abdulhadi *et al.* 1981) and drains are often blocked. This matter could lead to an increase in surface runoff and subsequent erosion (Burgess 1971, Liew 1974 *in* Kartawinata *et al.* 2001). In canopy gaps, the quantity of rainwater leaching the soil surface increases and the complete removal of ground vegetation, especially on clay soils, leads to the development of a dense rill network on slopes. Sediment load in rivers and streams in logged forests during low-flow periods can be two to three times higher than in primary forests; during storm flows, sediment loads can be as much as 20 times higher, depending on forest conditions (Liew 1974 *in* Kartawinata *et al.* 2001).

Logging activities can affect the physical and chemical characteristics of the soil. Some studies have confirmed that timber harvesting often leads to topsoil losses (where most biologically available nutrients are found), erosion, and accelerated leaching of nutrients (Douglas *et al.* 1993). An additional loss of nutrients occurrs when biomass is removed – as in trees extracted during logging.

Calcium, for example, illustrates the wider complexity of changing nutrient stocks and flows in disturbed forests. Calcium is commonly considered as a key mineral in the development of many vertebrate species (O'Brien 1998) and is likely to be a key factor causing the low abundance of many vertebrates in Malinau. In Kalimantan, forest clearance has been claimed to deplete calcium (Nykvist 1998). Losses of calcium could be also accelerated by increase of ground temperature when forests were cleared (Innes 1993). Fungi associated with decomposing woody litter might accumulate calcium and phosphorus making it less available temporarily to other organisms (also magnesium, manganese, copper, iron, nitrogen) (Coleman & Crossley 2003; Kurek 2002). Changes in nutrient availability, including calcium depletion and nitrogen retention, would have subtle, long-term effects on forest growth and composition.

Studies on erosion and its relation to logging of humid tropical forests indicated that erosion does increase during and after logging (Burgess 1971; Anderson 1972; Liew 1974; Siregar 2004). Some researchers have indicated an alarming increase of soil loss after logging. Anderson (1972) stated that losses from one ha in Brazil increased from two tons per year before logging to 34 tons per year after logging. Other physical effects on soils included loss of structure and compaction (Basuki & Sheil 2002). Undisturbed forest soils tend to have higher values for crumb stability and porosity and lower values for bulk density than soils that have been cleared (Siregar 2004).

Opening primary forest could reduce soil organic matter and in turn reduce the cation exchange capacity, which is largely controlled by colloidal organic matter derived from the above-ground biomass. Litter production is higher and the rate of litter decomposition is slower in primary forest compared to logged forests (Ewel & Conde 1980), which is caused by lower soil temperature in the primary forest. Mycorrhizal fungi, on which many tropical forest trees (especially dipterocarps) depend for facilitating their nutrient uptake, a severely affected by even slight increases in soil temperature, soil compaction and soil desiccation (Smits 1983)**.**

The objectives of the study

The study was undertaken in a lowland evergreen rain forest, dominated by dipterocarps in the Bulungan Research Forest, East Kalimantan, Indonesia (for site description see Chapter 2) in 2002-2005 to study the impact of logging on forest structure, regeneration, and soil properties. The study compared:

1) tree species composition, stem density, basal area, and coarse wood debris of four replicate 1-ha plots, from forest previously unlogged (PF), or logged with 30 year regeneration (LF-30), logged with 10 year regeneration (LF-10), and logged with 5 year regeneration (LF-5; Chapter 3);
2) the regeneration of seedlings and saplings across logging treatments (Chapter 4);
3) soil properties between unlogged and logged forest plots, and soil fertility and suitability for land conversion to agriculture (Chapter 5).

In addition, an assessment of the application of the Indonesian Selective Cutting and Replanting (TPTI) System was made (Chapters 3 and 4).

The hypotheses of the study

1) Do tree species composition, stem density, basal area, and coarse wood debris change after logging ? (Chapter 3)
2) Can timber be harvested sustainably from lowland tropical forest in Indonesia using the Indonesian Selective Cutting and Replanting (TPTI) system ? (Chapter 3)
3) Is the number of seedlings and saplings across logging treatments similar to the number of seedlings and saplings in primary forest ? (Chapter 4)
4) Do soil physical properties and soil chemical properties change after logging ? (Chapter 5)
5) Are soil fertility and soil sustainability maintained following land conversion to agriculture ? (Chapter 5)

CHAPTER 2. STUDY SITE AND ITS PHYSICAL ENVIRONMENT

East Kalimantan is known as a province with many economic activities, including logging, both legal and illegal. The study area is one of the major research sites used by the Centre for International Forest Research (CIFOR) and is known as the Bulungan Research Forest (BRF), or Malinau Research Forest, located in the district of Malinau, East Kalimantan, Indonesia. The BRF extends from 2^{o} 45' 12'' N; 115^{o} 48' 8'' E to 3^{o} 21' 4'' N; 116^{o} 34' 3'' E (Figure 1). The area is 321,000 ha and is adjacent to the Kayan Mentarang National Park. BRF has several concession holders, including P.T. INHUTANI I and P.T. INHUTANI II where this study was conducted.

STUDY SITE

The study areas are located in the timber concession area (ca 48,000 ha) of Perseroan Terbatas (P.T.) Inhutani II and includes the ex-concession area of P.T. Inhutani I, about 8 km from P.T. Inhutani II main base camp, where the primary forest was logged in 1974 (Figures 2 - 4).

The logging techniques used by P.T. Inhutani I and II were conventional as defined in the Indonesian Selective Cutting and Replanting System (TPTI). Under this system trees with dbh > 50 cm are harvested (See Appendix 12).

Forest condition in PF is shown in Figures 5. Figures 6 - 8 show the accessibility of the areas where the plots were located.

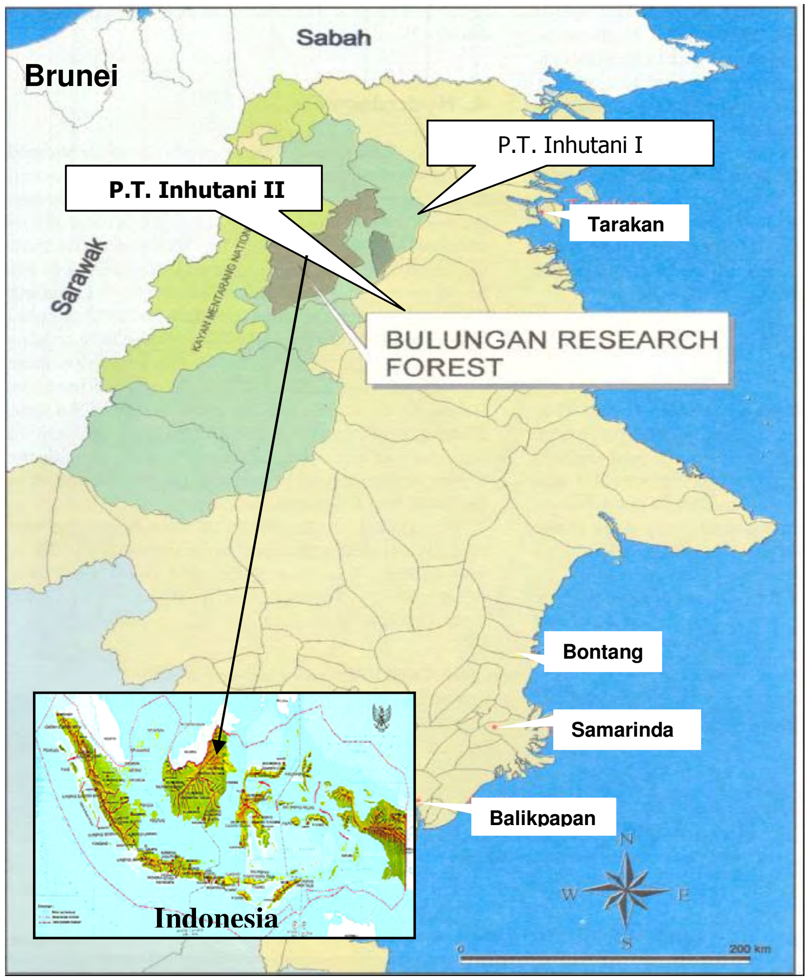

Figure 1. Location of the Bulungan Research Forest, Malinau, East Kalimantan, Indonesia.

Sources: Peta Administrasi Propinsi Kalimantan Timur, Scale 1: 1,1250,000 BAPPEDA (Land Resources Evaluation Project), 1999; Peta Administrasi dan Obyek Wisata, Kabupaten Bulungan, Scale 1: 800,000, Bappeda Tingkat II, Kabupaten Bulungan, Tanjung Selor; Landsat TM Path 117 Row 5820-04-1991; Landsat TM Path 118 Row 5808-01-1988; LandsatTM Path 117 Row 5822-05-1997 (*in* Machfudh, 2002).

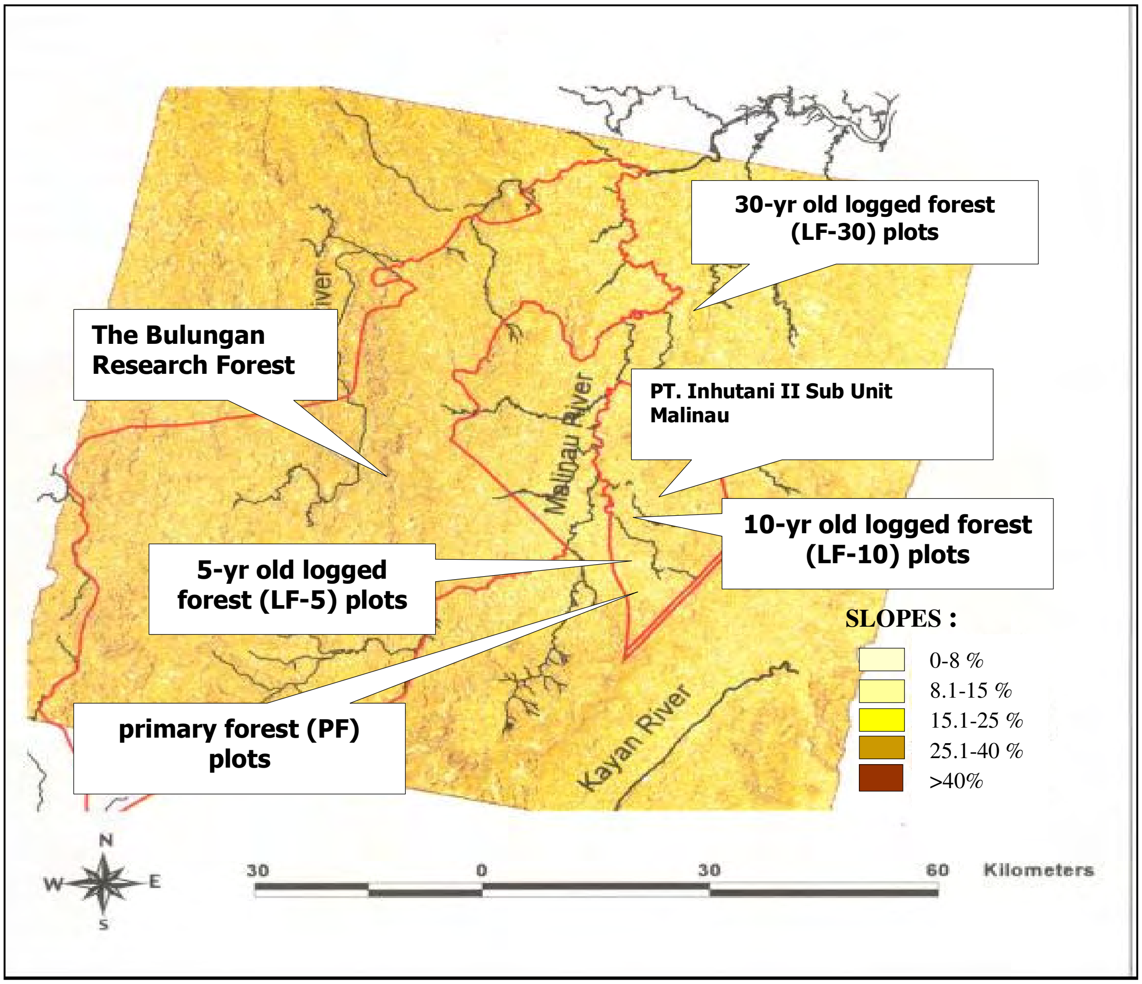

Figure 2. Slope distribution and plot locations in the study area.

Sources: Digital Elevation Model, 2000; Radarsat January, 2000; Landsat TM Path 117 Row 58 20-04-1991; Landsat TM Path 118 Row 58 08-01-1998; Landsat TM Path 117 Row 58 22-05-1997 (*in* Machfudh, 2002).

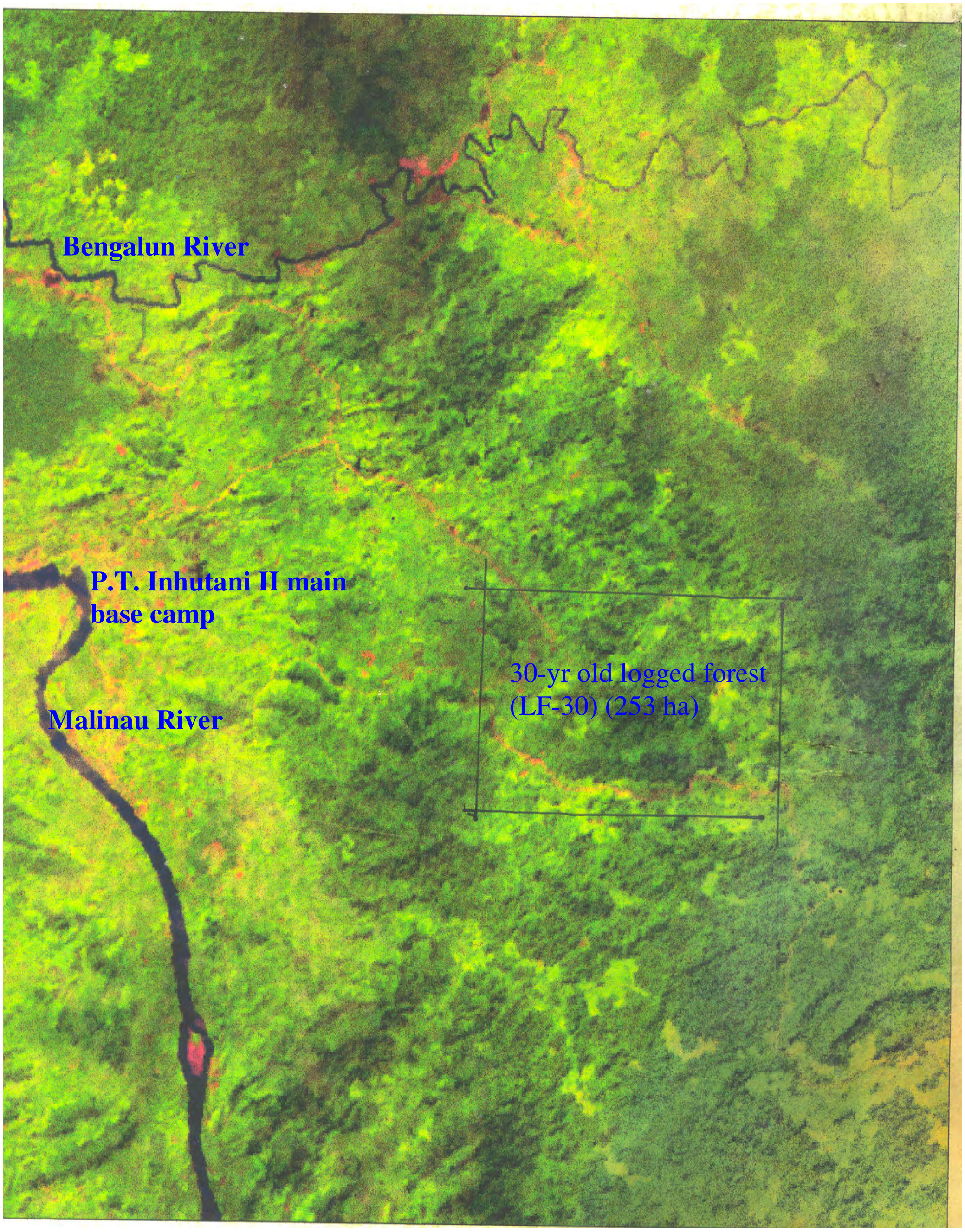

Figure 3. Satellite image of 30-yr old logged forest (LF-30), 8 km from P.T. Inhutani II main base camp.

Sources: Landsat TM-5 image of the Bulungan Research Forest.

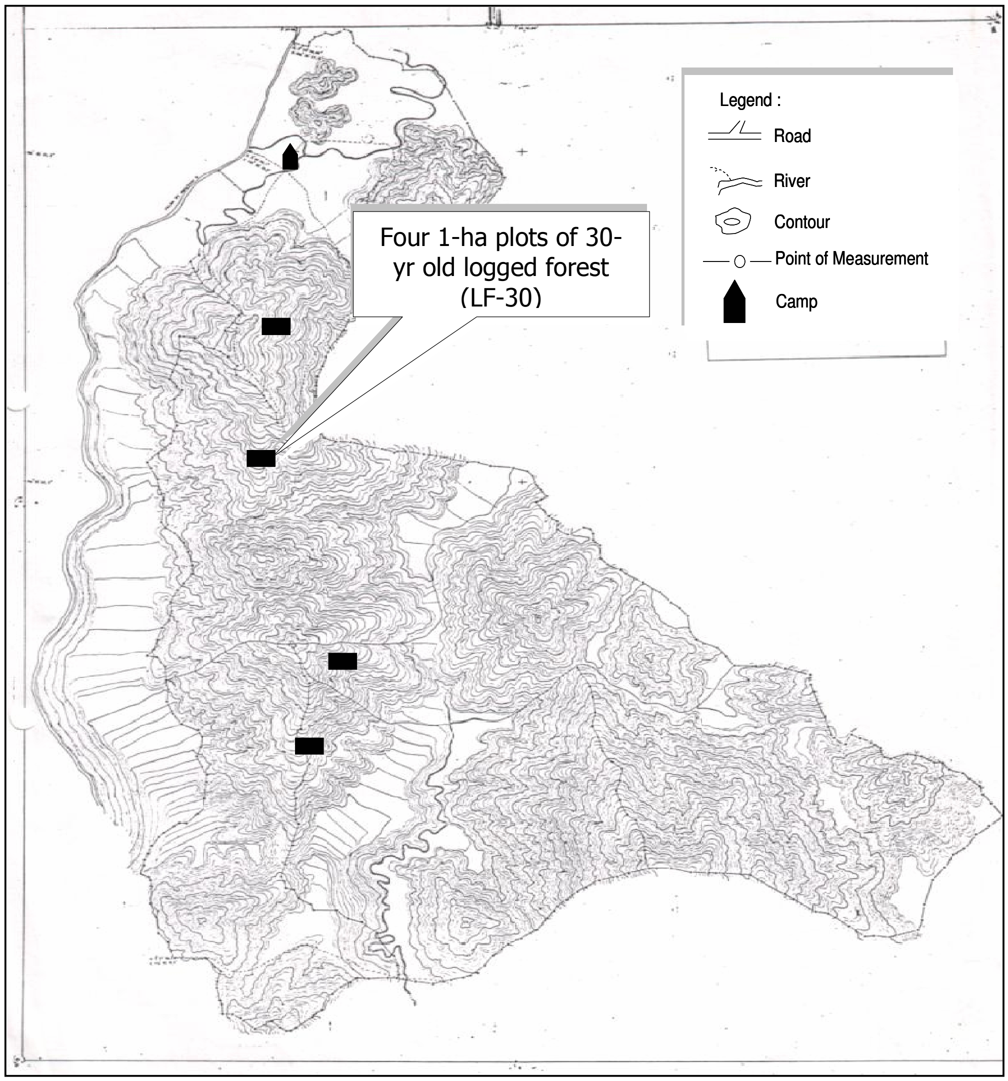

Figure 4. Thirty-year old logged forest (LF-30) plots in the concession area of P.T. Inhutani I, Malinau, East Kalimantan.

Sources: Peta Areal Wana Wisata Lokasi Km. 8 Tg. Lapang Tidung Pala Propinsi Kalimantan Timur, Scale 1 : 2.500, PT. Inhutani I Administratur.

Figure 5. Primary forest condition in the Bulungan Research Forest, East Kalimantan.

Figure 6. Large gap in logged forest in the Bulungan Research Forest, East Kalimantan.

Figure 7. Accessibility to the primary forest plots. The above photos showed a broken bridge due to sudden flooding a night before.

Figure 8. Accessibility to plot location in the Bulungan Research Forest with emergent *Koompassia excelsa* (white trunk) below.

TOPOGRAPHY

The topography is deeply eroded with a dense network of steep ridges and drainage gullies. Elevation at the logging site ranges from 100 to 300 m above sea level (asl). Overall, 84% of BRF is mountainous with an altitude range from 100 m. asl to almost 2000 m asl (Machfudh, 2002).

The slopes in most of the BRF area range between 25% and 40%. The condition is also similar in the area of P.T. Inhutani II Malinau where 40% of the area consists of slopes (Table 2).

Table 2. Slope distribution in the Bulungan Research Forest and P.T. Inhutani II concession area, East Kalimantan.

Slope Class (%)	Bulungan Research Forest (%)	P.T. Inhutani II (%)
0-8	22.23	9.80
8.1-15	25.06	13.44
15.1-25	0.23	30.04
25.1-40	39.97	37.74
>40	12.50	8.08

Source: Machfudh 2002

GEOLOGY

The geology of the area is highly diverse (Table 3 and Figure 9). Formations include volcanic, metamorphic and tertiary and quaternary sedimentary rocks (including coal, limestone, sandstones and siltstones, etc.), and extensive alluvial deposits (Machfudh 2002).

Table 3. Distribution of geological groups in the Bulungan Research Forest, East Kalimantan.

No	Rock Formation	Percentage (%)
1	Lurah Formation Embaluh Group	16.47
2	Mentarang Formation Embaluh Group	54.41
3	Paking Formation	0.29
4	Sembakung Formation	0.29
5	Metulang Volcanic	9.12
6	Langap Formation	2.94
7	Jelai Volcanic	7.06
8	Alluvium	< 0.01
9	Plug Dyke	< 0.01

Source: Geological Research and Development Centre 1995 (*in* Machfudh, 2002).

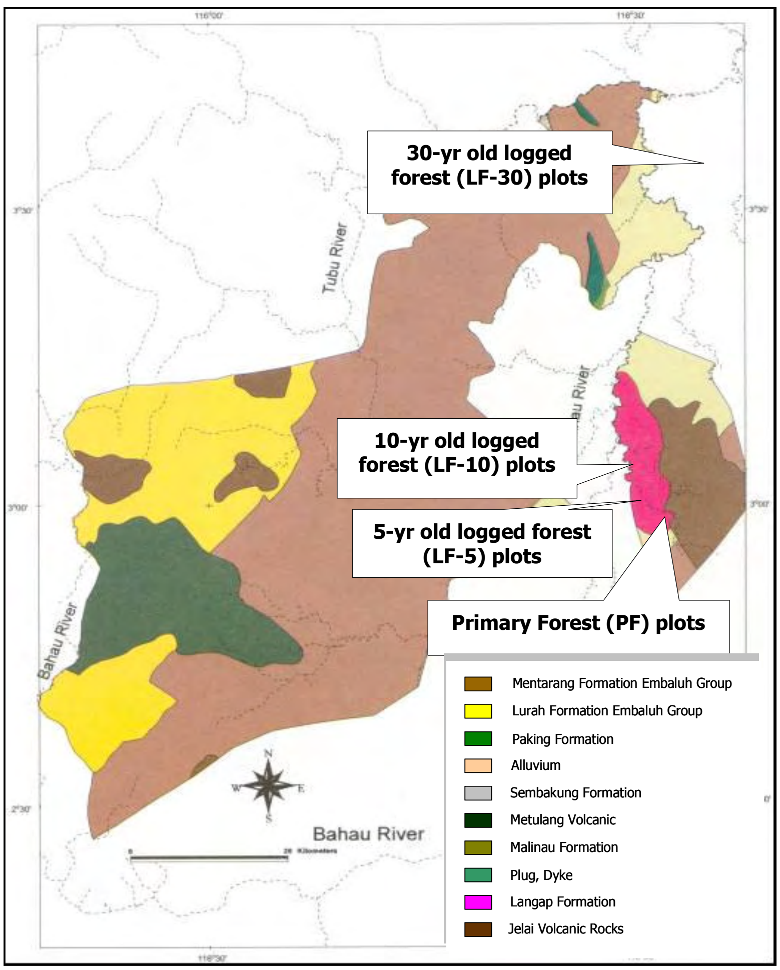

Figure 9. Geology of Bulungan Research Forest, East Kalimantan.

Sources: Geological Research and Development Center (1995) Geological Map sheets of Malinau and Longbia (Napaku), Kalimantan. Scale 1: 250,000. GRDC, Bandung (*in* Machfudh, 2002).

SOILS

The soils in the Bulungan Research Forest range from strongly weathered and acid ultisols to young inceptisols. Most of the Bulungan Research Forest area is dominated by three soil groups of the USDA soil classification: (1) Typic Tropaquepts (2) Typic Kanhapludults and (3) Dystropeptic Tropadults (Figure 10; Machfudh 2002, REPPProT 1978).

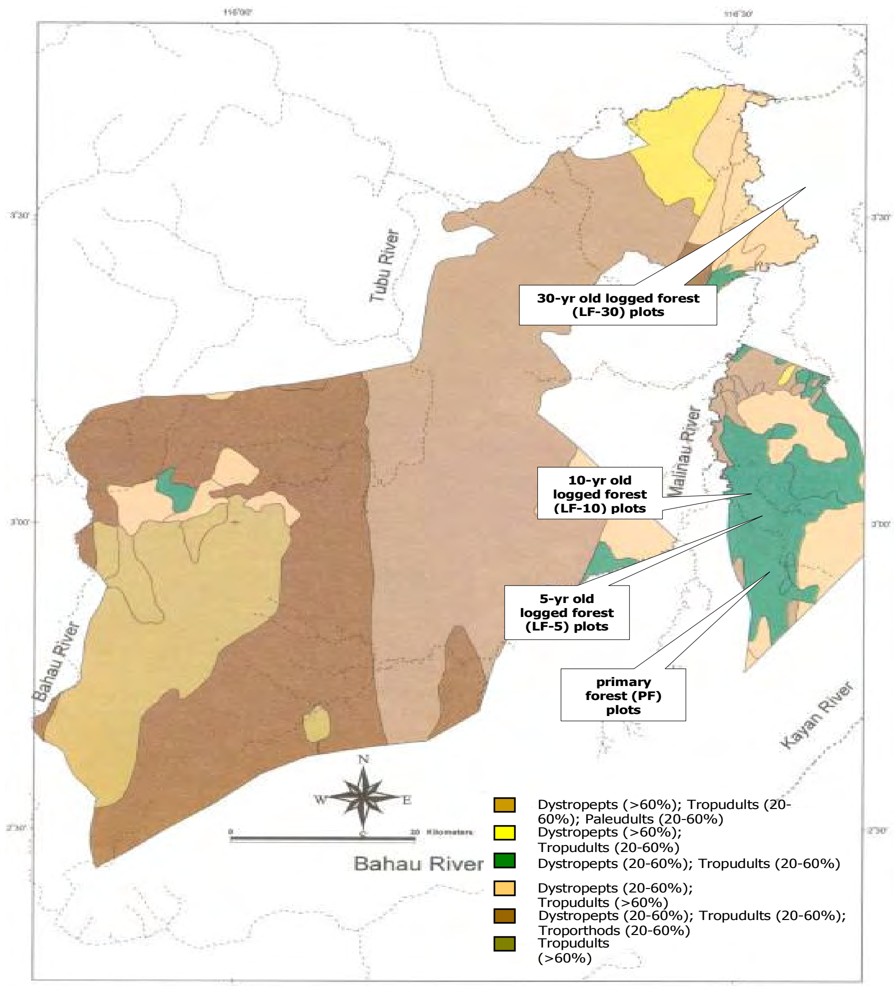

Figure 10. Soil type distribution in the Bulungan Research Forest, East Kalimantan.

Source: Land system and land suitability map of Malinau Sheet 1819. Series RePPProt 1987. Land system and land suitability map of Malinau Sheet 1818. Series RePPProt 1987. (*in* Machfudh, 2002).

CLIMATE

The climate of the study area is humid, belonging to rainfall type A according to Schmidt and Ferguson (1951) with a dry season less than two months and the wet season more than nine months, typically from April to December.

Precipitation

For Malinau District the mean annual rainfall was 3,828 mm/year between 1922 and 1980 and the number of rain days was 143 days/year (Table 4). Meteorological data for the BRF are available from the Binhut camp of P.T. Inhutani II at Km 74 and Seturan station of CIFOR at Km 90 for 1999-2002 (Figure 11). The mean number of rainy days and average precipitation (mm/month) at the study area ranged from 7 to 25 and 102 to 525 respectively while in Malinau district these ranged from 2 to 25 and 30 to 379 respectively.

Table 4. Rainfall analysis summary at the Malinau District Meteorological Station, East Kalimantan in period 1922 – 1980.

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
MONTHLY RAINFALL		MEAN	230	191	251	270	360	332	345	335	368	369	379	299	3828
		MAXIMUM	487	472	470	581	711	573	834	802	671	881	977	681	6237
		MINIMUM	67	40	52	95	131	138	147	90	37	60	30	90	2428
		SD	100	112	114	150	134	109	147	177	136	182	172	130	822
		CV	0.4	0.6	0.5	0.6	0.4	0.3	0.4	0.53	0.4	0.49	0.45	0.44	0.21
		MAXIMUM IN ONE DAY	126	188	215	160	170	152	188	185	205	155	138	174	
10 DAYS MEANS		PERIOD													
		1 (1-10)	78	66	72	95	115	114	115	109	141	126	128	106	
		2 (11-20)	82	77	94	90	111	85	97	119	110	133	137	115	
		3 (21-end)	70	50	85	84	133	133	132	108	116	109	114	78	
RAINDAYS		MEAN	12	9	11	11	12	12	12	12	13	13	13	12	143
		MAXIMUM	20	18	19	20	19	21	18	19	25	20	21	19	184
		MINIMUM	5	2	3	2	5	5	4	3	3	6	5	6	85
		SD	4	3	4	4	4	4	3	4	4	4	4	3	24
		CV	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2
EXCEEDENCE PROBABILITY		10%	359	330	398	458	535	475	535	559	546	601	600	467	4911
		20%	299	260	329	365	457	413	447	449	466	490	496	389	4473
		50%	211	165	229	236	337	315	317	296	345	331	345	274	3743
		80%	149	104	159	153	249	241	225	195	256	224	240	193	3131
		90%	124	82	131	122	213	209	188	157	218	182	198	161	2852
		95%	107	68	112	101	187	187	162	131	192	154	170	139	2642
		98%	90	54	94	82	161	164	137	107	166	127	142	117	2422
DROUGHT DURATION ANALYSIS	DRY DAYS	MEAN	10	11	9	10	8	7	8	8	8	8	8	8	
		SD	5	5	5	4	4	3	3	4	3	5	4	3	
	RETURN PERIOD	1 in 2	9	10	8	9	7	6	7	7	7	7	7	7	
		1 in 5	13	14	12	13	11	9	10	11	10	11	11	10	
		1 in 10	16	17	15	15	13	11	12	13	12	14	13	12	
		1 in 20	19	20	18	17	16	13	14	16	14	17	16	14	
		1 in 50	24	24	23	20	19	15	16	19	16	22	19	16	
No. of records			34	36	36	37	34	34	35	36	36	35	37	36	29

Source: Dinas PekerjaanUmum KalimantanTimur. (1982). Rainfall records, East Kalimantan. SD, standard deviation; CV, coefficient of variation.

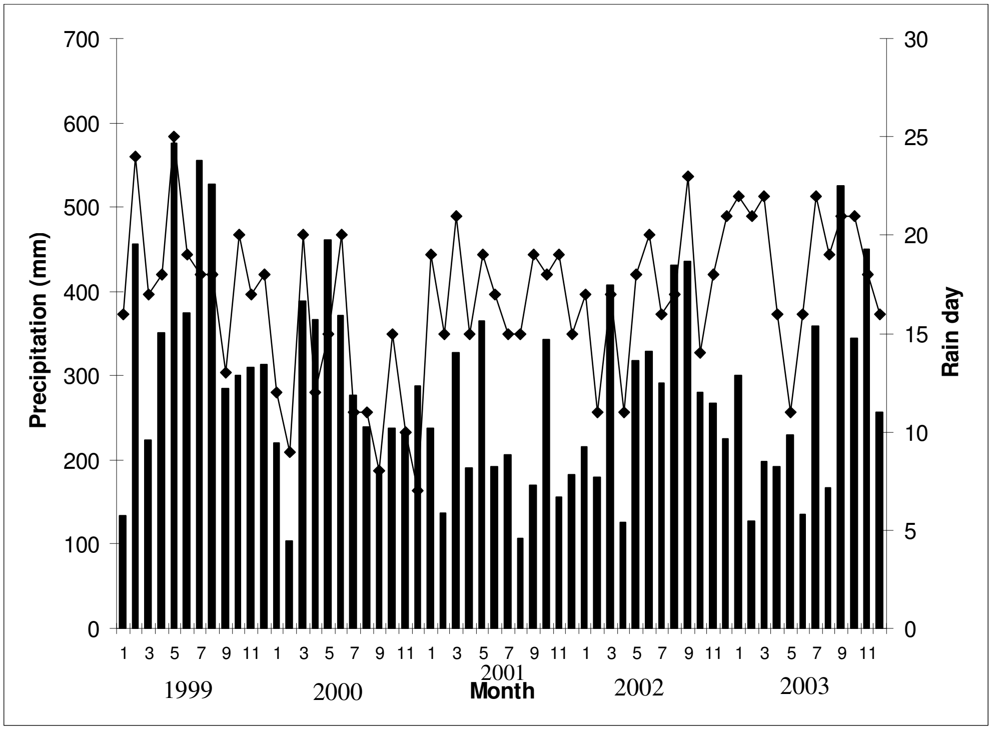

Figure 11. Mean monthly precipitation (mm) recorded at Seturan station of CIFOR, 1999–2003 in the Bulungan Reseacrh Forest, East Kalimantan.

Note: Monthly average precipitation and the number of rainy days in 2001 were the average taken from 2 stations, namely Seturan Station of CIFOR in km 90 and Binhut camp of PT Inhutani II in km 74. Source: Seturan station of CIFOR 2001-2003 and Binhut camp of PT Inhutani II 1999 – 2001.

Temperature and humidity

The highest temperature (34^0C) in the Inhutani II concession area occurred on cleared land and the lowest temperature recorded (23.5^0C) was measured in unlogged forest. Relative humidity ranged from 75% to 98%.

Seturan station of CIFOR (2000-2003) where most of my study was done recorded a highest temperature of 38.0^0C and the lowest of 22.2^0C (Table 5).

The temperature in Bulungan Research Forest Station was relatively constant throughout the year (Figure 12). The daily average temperature ranged from 24.1^{0}C (January) – 27.2^{0}C (May) and the maximum temperature ranged from 29.2^{0}C (January) – 32.7^{0}C (September).

Table 5. Temperature and relative humidity recorded in Bulungan Research Forest Station 2000 – 2003.

Month	2000			2001			2002			2003		
	H	T	T Max	H	T	T Max	H	T	T Max	H	T	T Max
	(%)	(^{0}C)	(^{0}C)	(%)	(^{0}C)	(^{0}C)	(%)	(^{0}C)	(^{0}C)	(%)	(^{0}C)	(^{0}C)
January	86.3	25.0	33.0	89.0	26.0	33.0	82.8	23.3	26.3	79.9	22.2	24.6
February	86.0	25.3	33.0	87.7	26.0	31.0	90.4	25.6	29.0	90.2	25.3	29.1
March	85.3	25.5	35.0	88.0	26.3	33.0	89.4	26.3	29.6	89.9	26.1	29.5
April	86.0	26.5	33.0	86.3	26.7	33.0	86.8	26.6	30.0	87.9	26.7	30.7
May	80.5	27.3	34.0	86.7	27.3	32.0	87.6	26.8	30.4	86.2	27.3	33.5
June	85.7	26.3	33.0	85.7	27.0	33.0	89.4	26.7	30.0	86.7	26.6	33.4
July	82.0	26.5	33.0	86.3	24.0	31.0	87.7	27.0	30.1	88.4	25.7	29.7
August	82.5	27.0	33.0	85.3	27.3	34.0	87.9	26.4	30.1	88.9	26.4	30.1
September	83.0	26.6	38.0	82.7	27.3	33.0	90.0	25.9	29.8	89.9	25.0	30.1
October	84.3	27.2	35.0	89.0	26.7	31.0	89.5	26.4	30.0	91.2	22.7	28.2
November	85.7	26.7	32.0	90.0	27.0	32.0	89.7	26.6	29.9	89.1	26.3	31.8
December	88.7	26.3	32.0	87.0	26.3	31.0	91.3	26.2	29.4	83.9	23.0	26.7
Mean	84.7	26.3	33.0	87.0	26.8	32.3	88.6	26.1	29.6	87.7	25.3	29.8

Source: Seturan station of CIFOR. H, relative humidity; T, mean temperature; T max, mean of temperature maximum.

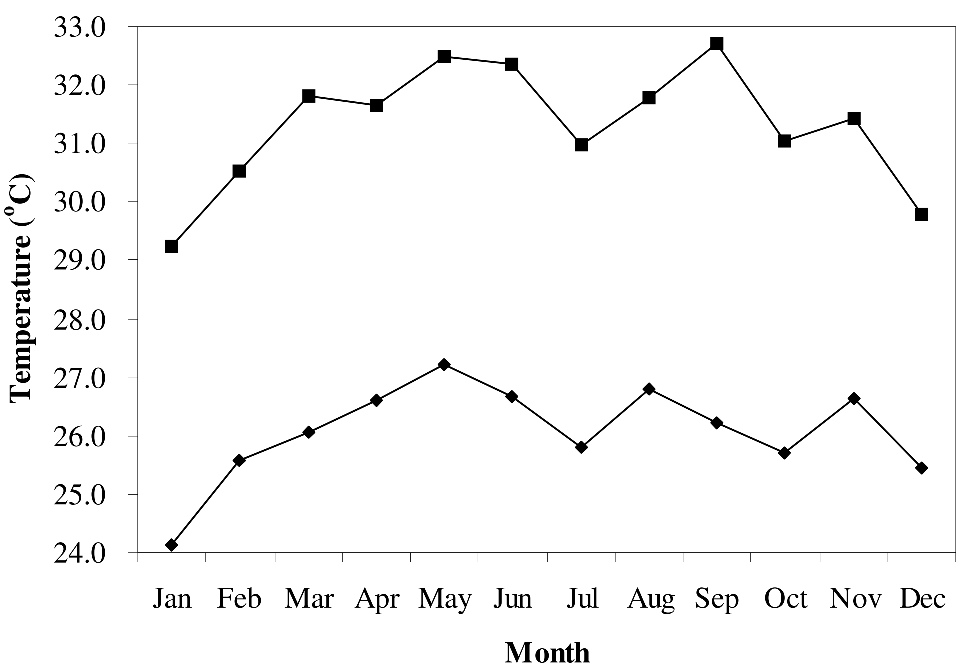

Figure 12. Maximum (■) and average (♦) temperature at Seturan station of CIFOR in the Bulungan Research Forest, East Kalimantan.

Relative humidity in the area was high. The most humid months were October and December with an average relative humidity of 91.2% and 91.3% respectively. The least humid months were January and May with 79.9% and 80.5% relative humidity respectively (Figure 13).

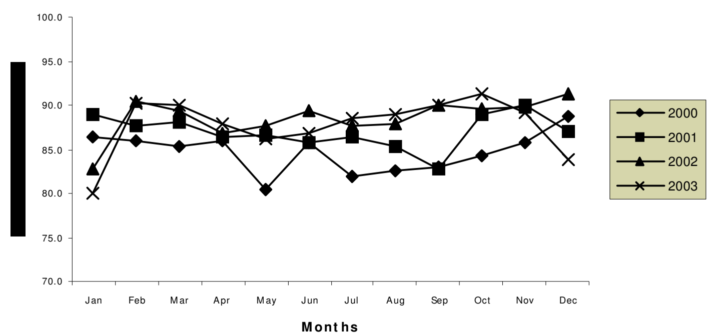

Figure 13. Monthly relative humidity between 2000-2003 in Seturan station of CIFOR in the Bulungan Research Forest, East Kalimantan.

Vegetation types

The BRF is covered entirely by tropical rain forest. This area is now become one of the remaining frontier forest in Asia (Machfudh 2002). According to Landsat TM-5 imagery taken in 1997 (Figure 14), the BRF consist of primary forest (97.84%), secondary forest (2.21%) and opened lands (0.04%). The floristic zones of the area can be seen in Figure 15. The BRF is divided into four forest types, namely lowland dipterocarp forest, sub-montane forest, riparian forest and alluvial forest. Dominant species with DBH ≥ 10 cm is from the family of Dipterocarpaceae (Machfudh 2002). According to O’Brien *et al.* (1998 *in* Machfudh 2002) 60% of the tree families and 36% of the tree genera known in Kalimantan occurred in BRF.

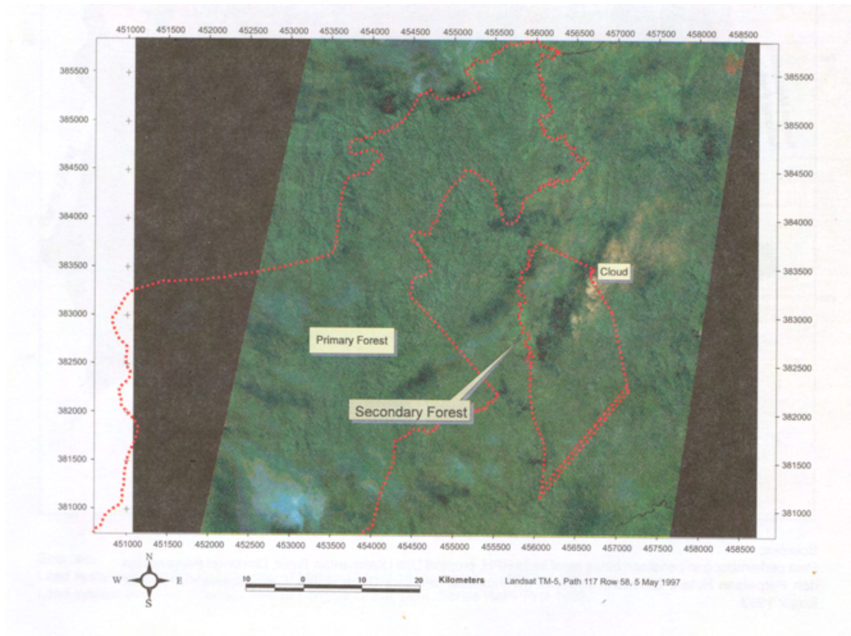

Figure 14. Landsat TM-5 image of the Bulungan Research Forest.

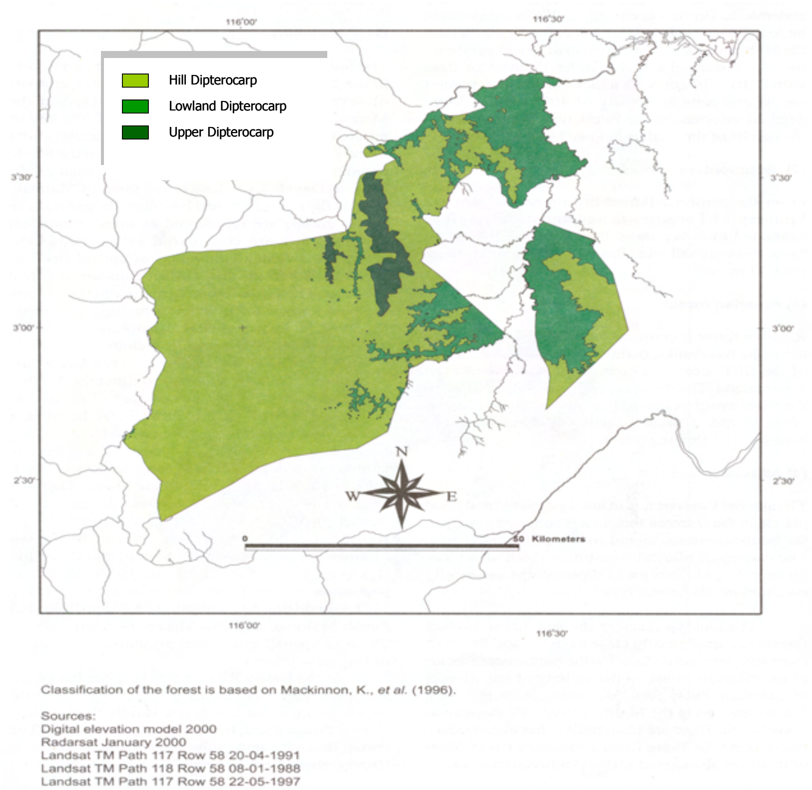

Figure 15. Floristic zones in the Bulungan Research Forest.

Population densities

The BRF area especially the Malinau watershed is inhabited by various ethnic groups, such as the Punan, Kenyah, Merap, Abai and Putuk with the largest one is the Punan. According to Levang *et al*. (2002), the Punan is the largest remaining population of hunter gatherers in Asia.

Other groups such Moslem Dayak, including the minority Javanese and Madurese transmigrants, mostly live near the district of Malinau. In general, those groups are known as forest dependent people (Machfudh 2002; Meijaard *et al.* 2005) The population density in Malinau District area is low. Only about 5 – 6000 individuals are distributed over an area of ca. 300,000 ha or about 2 individuals per km^2 (Machfudh 2002).

The forest area was used by indigenous Dayak communities who practiced shifting cultivation and harvested non-timber forest products (Kartawinata *et al.* 2002) and has very high values to many people living and around including communities in Malinau watershed. However, since the beginning of commercial timber exploitation in the late 1960's, those values are disturbed even up to the present. Four decades after timber exploitation began, forest remains one of the major factors for foreign exchange for the district and central governments.

There are so many negative impacts due to forest exploitation ecologically and economically. Local people who are known as a forest dependent are not able to practice their traditional activities any more as they lose access to the forest and forest resources.

Forest products provide subsistence goods (staple food, vegetables, fruits, game and fish), cash income (eagle wood, bezoars stone, rattan, resin and gum), building materials and medicinal plants. Considering the importance of forests to local people, we can easily imagine that local people would suffer most from forest exploitation.

Logging activities

The forest in BRF was in a good condition up to the late of 1960s when commercial logging were started around Malinau sub-district (Inhutani I staff, 1999 pers.comm.).

The Indonesian Selective Cutting and Replanting system has been implemented from the beginning of logging activity in BRF, where all dipterocarp species with a diameter at breast height (dbh) of over than 50 or 60 cm can be harvested with a polycyclic feeling schedule of 35 years. In the highly productive dipterocarp forests, harvesting intensity commonly exceeds 100 m^3/ha^{-1} or more than 10 $trees/ha^{-1}$ (Sist *et al*. 2002). In extreme conditions, extracted timber volume in BRF reached 150 m^3/ha (Priyadi 2005 pers.comm). According to Sist *et al*. (2002), the maximum harvesting intensity sufficient to sustain forest condition in BRF is 80 m^3/ha.

CHAPTER 3. FLORISTIC COMPOSITION AND FOREST STRUCTURE IN UNLOGGED AND LOGGED STANDS

INTRODUCTION

Selective logging typically results in the destruction of about 50% of all trees present before logging (Johns 1992, Whitmore 1984), but this can vary greatly with the stocking density of commercially viable timber species, which is, in turn, dependent upon the botanical composition of the trees, current economic conditions and the methods of exploitation. Logging may create large gaps which allow the development of early succession vegetation and eventually influence the floristic composition and stand structure (Whitmore 1984).

After more than 30 years of industrial logging activities in Indonesia, relatively few studies are available on the tree species composition in permanent sample plots (PSP), especially in Kalimantan. Long-term studies of species composition and turnover, using permanent sample plots in tropical rain forest are scarce because they are time consuming, difficult to maintain and therefore very expensive (Sheil 1998). Some of the world's longest-term PSPs such as Budongo Forest in Uganda (Sheil 1995) or in Pasoh, Malaysia (Appanah 1998) have provided long-term data from both primary and treated tropical forest. Data from PSPs in Kolombangara, Solomon Islands are another good example, where forest dynamics studies spanned 34 years in 1998 (Burslem *et al.* 1998). Long-term studies, using PSPs are particularly important in Indonesia. PSPs, established in sites where their maintenance can be ensured, will provide much needed information and play a major role both for ecological research and forest management (Sheil 1995).

This chapter reports tree diversity, frequency and density based on data collected from 16 1-ha PSPs. The four sites had different ages of regrowth after logging, four plots at each site, namely 5, 10 and 30 years after logging as well as 4 plots in unlogged forest for control, as described in Chapter 2. The main objectives of the study were to evaluate the:

- existing condition of trees in logged and unlogged forest;
- use of the Indonesian Selective Cutting and Replanting System as applied in the BRF; and
- sustainability of timber harvest in the BRF in general from lowland tropical forest in Indonesia.

METHODS

Sampling design and description of study plots

A replicated, stratified-random sampling of primary forest and sites logged at various times in the past was used. The method of establishing all PSPs in the study areas was based on the techniques proposed by Dallmeier (1992), Alder & Synnott (1992) and Sheil (1998).

Six blocks of about 100 ha each were selected after examining the inventory of Residual Plants Maps of P.T. Inhutani I and II. The information on the map was cross-checked with senior staff of P.T. Inhutani I and II who worked on the site before. Blocks 55, 56 and 64 are in primary forest (PF), 85 km from the P.T. Inhutani II main base camp; the forest logged five years before the study, in 1998/1999, (LF-5) is 77 km, the forest logged 10 years before study, in 1992/1993, (LF-10) is 57 km, and the forest logged 30 years before study, in 1974/1975, (LF-30) is 8 km from P.T. Inhutani II main base camp (Table 6).

All sites belong to P.T. Inhutani II, with the exception of LF-30, which belongs to P.T. Inhutani I. Within the blocks of ca. 100 ha, the position of the 1-ha plots was taken at random. In all, 16 PSP were established for this study, four in each of PF, LF-5, LF-10, and LF-30 (Table 6).

Each plot was subdivided into 25 20 m x 20 m sub-plots. The centre of every plot (sub-plot 13) was marked with a 2-m long iron wood stake (10 cm x 10 cm in cross section) which was driven 1 m deep into the soil, with the aerial part painted white. The plot corners were clearly marked with 50 cm painted PVC and metal pipe (2.54 cm or 1 inch in diameter) stakes with a tag. Additional PVC stakes were located at every 20 m interval along each side.

Table 6. Permanent sample plots with plot treatment in the Bulungan Research Forest, East Kalimantan, Indonesia 2002-2005.

Code	Plot No	Description	Date of recording	Treatment
LF-30	01 02 03 04	30-yr old logged forest (Block 22); PT Inhutani I; 03^{O} 27.607' N to 116^{O} 35.287' E	Feb-Mar 2002 and Sep-Dec 2002	Heavily logged in 1974/75, mainly for dipterocarp species
PF	01 02 03 04	Primary forest (Blocks 55,56, 64); PT Inhutani II; 02^{O} 58.527' N to 116^{O} 30.045' E; 02^{O} 57.957' N to 116^{O} 30.555' E	Apr 2002 - Aug 2002	Dipterocarp-rich primary forest, planned to be logged in 2003
LF-10	01 02 03 04	10-yr old logged forest (Block 70,72); P.T. Inhutani II ; 03^{O} 07.750' N to 116^{O} 29.001' E	Jan 2003 - Apr 2003	Heavily logged in 1992/93, mainly for dipterocarp species
LF-5	01 02 03	5-yr old logged forest (Blocks 39, 40); P.T. Inhutani II ; 03^{O} 00.502' N to 116^{O} 30.572' E ; 03^{O} 00.327' N to	May 2003 - Jan 2004	Heavily logged in 1998/99, mainly for dipterocarp species

Code	Plot No	Description	Date of recording	Treatment
	04	116^{O} 30.604’ E		

Trees with a diameter ≥ 10 cm dbh were recorded from every 20 m x 20 m sub-plot. All recorded trees were labelled with aluminium tags and aluminum nails at 140 cm above ground (Figure 16). Girth was measured 10 cm below the nail except where buttresses distorted the trunk; on such trees girth was measured 30 cm above the protrusion and a second nail marked 10 cm above the point of measurement. For multiple stemmed trees all trunks ≥ 10 cm dbh were measured and the points of measurement marked with a nail as described above. Only the largest trunk was tagged.

Tree height was measured by using a clinometer. The horizontal distance (X) from the base of the trees to the point of measurement was at least 20 m. Two clinometer readings were taken, one from point of measurement (POM) to the tree base (A1) and another to the top of the crown (A2).

Tree height was calculated using the formula:

$$\textit{tree height (m)} = X\ (\textit{tangent } A1 + \textit{tangent } A2)$$

Tree circumference was measured by a tape and values were converted to dbh values.

Identification and determination of species

Field identification of tree species was made by observation using binoculars (Figure 17). Specimens were collected from each tree either by using a catapult or by tree climbers (Figures 17 and 18). The specimens were air dried in the field and were identified at the Herbarium Bogoriense, Biological Research and Development Center, Indonesian Institute of Sciences, Bogor, and the Wanariset Herbarium, Forest Research Institute, Samarinda, East Kalimantan.

Figure 16. Making of tag (above) and tagged tree

Figure 17. Tree observation using binoculars (above); taking of leaf using *catapult*

Figure 18. Modern climber equipment (above); and tree identification in the field

For the identification keys found in various Floras, Manuals and Revisions including Index Kewensis, Checklist of Generic Names (van Steenis 1987), Tree Flora of Indonesia (Checklist by Whitmore *et al.* 1990), Tree Flora of Malaya and Lists of collections stored in Wanariset Herbarium (Sidiyasa *et al*. 1999) were used and determinations were checked against herbarium specimens lodged in the Herbarium Bogoriense and Wanariset Herbarium.

Species-area curves

In order to determine whether the species recorded in a 1-ha plot represented the number of species in the area studied, a species-area curve was constructed. Species data from the subplots within each hectare were systematically added to calculate a mean species/area curve for 1-ha with standard deviations. EstimateS calculates mean from all possible permutations of samples.

Basal areas

The basal area of trees was calculated as:

$$BA = \left(\frac{dbh}{2}\right)^2 \pi$$

where *BA* is basal area, π is constant (3.14) and *dbh* is diameter at breast height.

Species diversity and equitability indices

The species diversities among plots were compared by using the Shannon-Weiner diversity index (H) according to the equation (Clifford & Stephenson 1975):

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where s is the number of species, p_i is the proportion of the individuals of the ith species to the total number of stems and *ln* is log 10 base.

The equitability among plots were compared using the equation:

$$E = H/H_{max}$$

where E is equitability, H is Shannon's diversity index and H_{max} equals ln (total number of species in H).

Statistical analyses

The statistical significance of differences among treatments means was assessed using one-way analyses of variance (ANOVA). Where results indicated significant ($p<0.05$) treatment effects, Tukey's HSD test was used to determine the levels of significance among the treatment means. The data were analysed using Microsoft Excel 2003 and JMP 5.1 statistical programme published by SAS Institute in United States (Sall *et al*. 2005).

Similarity analyses

The similarity between forest types was measured with the Sorensen and Jaccard indices using the freeware EstimateS (http://viceroy.eeb.uconn.edu/estimates).

RESULTS

Species richness estimation

Among all forest types, the highest species number (4 1-ha) occurred in LF-5 (408 species) and the lowest was found in PF (383) (Table 7). Sampling efficiency that calculated as a percentage of observed versus expected species, did not vary significantly between forest type and estimators (using six different estimators); with the exception of the Jack 2 estimator that yielded the most extreme values. Sampling efficiency was, however, lowest value in LF-10 varying between 61.3 – 67.4%. Sampling efficiency reached the highest value in LF-30 varying between 70.0 – 87.5% (Table 7). For an easier assessment of sampling efficiency, the mean of the six estimators was calculated and compared with the observed species (Fig. 19).

Table 7. Species number of the different species estimators for the plant communities in each forest type. Percentages of estimated species to observed species are given in italic. Lowest and highest estimates of sampling efficiency are given in bold

Block	Species Number	ICE	%	Chao2	%	Jack1	%	Jack2	%	Bootstrap	%	MM Mean	%
PF	383	524.9	*73.0*	518.8	*73.8*	511.6	*74.9*	580.3	*66.0*	441.4	*86.8*	467.2	*82.0*
LF-5	408	599.7	*68.0*	567.9	*71.8*	553.0	*73.8*	632.8	*64.5*	473.2	*86.2*	533.4	*76.5*
LF-10	384	495.6	*61.3*	478.7	*63.5*	451.1	*67.4*	490.4	*62.0*	457.6	*66.4*	465.8	*65.3*
LF-30	404	522.8	*77.3*	506.4	*79.8*	526.0	*76.8*	577.5	*70.0*	461.7	***87.5***	506.0	*79.8*

Note: ICE = Incidence-based Coverage Estimator, MM Mean = Michaelis-Menten Mean

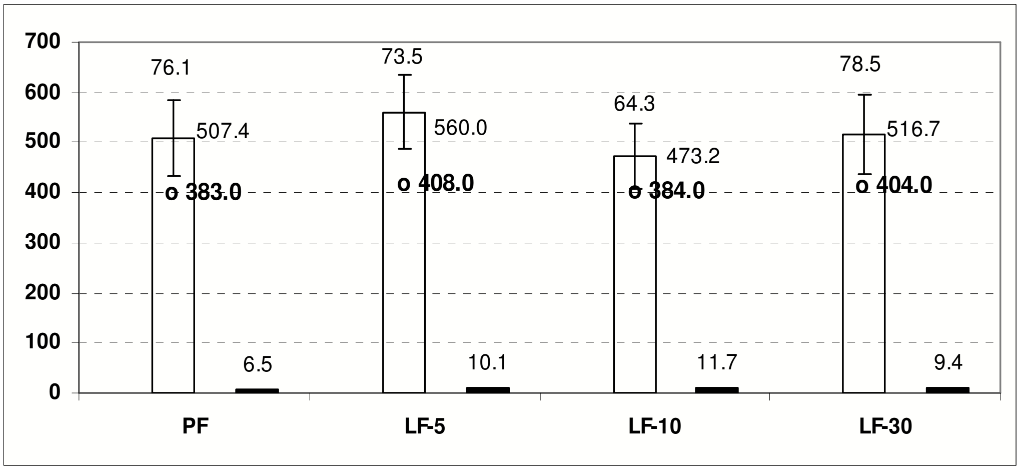

Figure 19. Overall estimator mean (white bar), observed species (sphere) and mean SD of estimator (black bar) in the different forest types. Sampling efficiency (observed/estimated species) is given as percentage.

The similarity in tree species composition

The lowest value of the similarity index (Jaccard and Sorensen index) was found between LF-10 and LF-5 (0.189 and 0.317), though low similarity values were also found among forest types varying between 0.189 – 0.235 (for Jaccard index) and 0.317 – 0.380 (for Sorensen index) (Table 8).

Both correlation values, r = 0.023 for Jaccard index and r = 0.031 for Sorensen index showed no strong correlation between the similarity index (C) and the distance between forest type, as the assumption for strong correlation is $0.5 \le r \le 1.0$. In the correlation significant test, based on its hypotheses H0: p = 0.5; H1: $p \neq 0.5$. Those two indexes also did not show any significance.

Table 8. Matrix of similarity in the tree species compositions among four forest types

Jaccard index				
	PF	LF-5	LF-10	LF-30
PF		0.227	0.228	0.235
LF-5	189		0.189	0.196
LF-10	152	145		0.217
LF-30	156	138	217	
Sorensen index				
	PF	LF-5	LF-10	LF-30
PF		0.369	0.370	0.380
LF-5	189		0.317	0.327
LF-10	152	145		0.356
LF-30	156	138	217	

Note : Values in top right are the indices of similarity (Jaccard and Sorensen index) and numerals in lower left part are numbers of species shared between each plot; number of species found in PF is 383 species/4 ha can be seen in Table 9

Species-area curves

The species area relationship showed that a considerable number of additional species was encountered more or less steadily up to the full plot size of 1-ha, without any indication of leveling off, which implies that a 1-ha plot does not capture the regional species richness (Figure 20). The calculation species accumulation curves of the LF-5 lied above the curves of PF, LF-10 and LF-30 (Figure 21). Generally the slopes of the species accumulation curves of the different forest types tended to be similar.

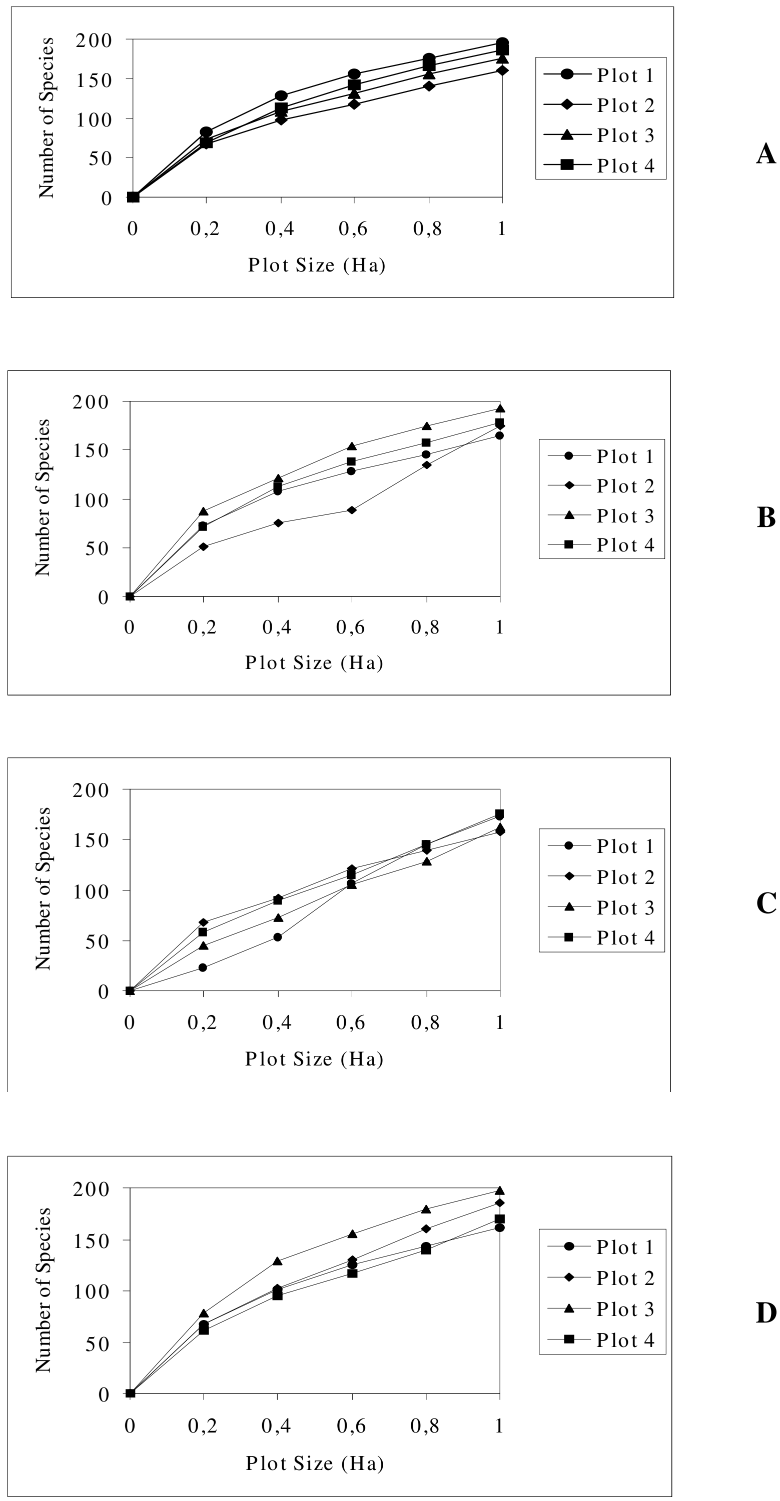

Figure 20. Species-area curve for trees with dbh ≥ 10 cm in 1-ha plots of a lowland forest PF (A), LF-5 (B), LF-10(C) and LF-30 (D), by plotting the number of species against the cumulative area of sub-plots of 20 m x 20 m each.

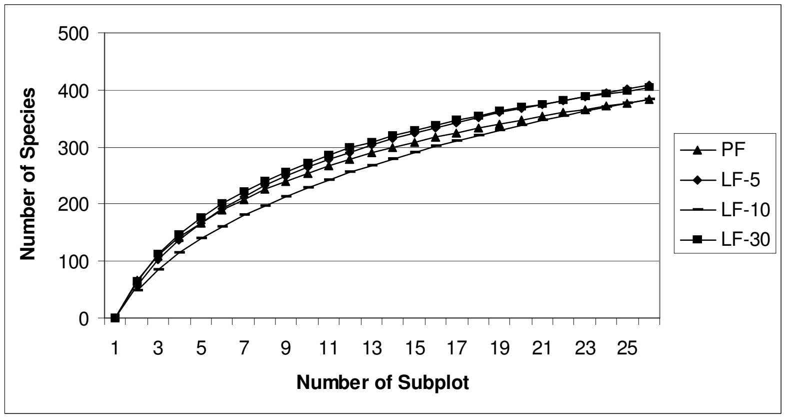

Figure 21. Species accumulation curves for trees with dbh ≥ 10 cm in 4-ha plots of a lowland forest PF (A), LF-5 (B), LF-10(C) and LF-30 (D), by plotting the number of species against the cumulative area of sub-plots of 20 m x 20 m each. Graph obtained by EstimateS.

Species numbers, tree densities and basal area

Overall, there were 914 species (dbh ≥ 10 cm) of 223 genera and of 65 families in the 16 plots. The number of families to which the species belonged was 54 in PF, 57 in LF-5, 57 in LF-10 and 51 in LF-30. The corresponding number of genera was 147, 159, 154 and 150, respectively (Table 9).

Table 9. Combined totals of taxonomic richness, number of trees and basal area over four 1-ha plots in PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan

	PF	LF-5	LF-10	LF-30
Number of families	54	57	57	51
Number of genera	147	159	154	150
Number of species (N/4 ha)				
Dipterocarpaceae	46	45	35	43
Non-Dipterocarparceae	337	363	349	361
Total	383	408	384	404
Number of trees (N/4 ha)				
Dipterocarpaceae	758	360	279	632
Non-Dipterocarpaceae	1663	1643	1725	1674
Total	2421	2003	2004	2306
Basal Area (m^2/4 ha)				
Dipterocarpaceae	109.2	36.7	31.8	72.2
Non-Dipterocarpaceae	74.0	77.2	98.6	115.5
Total	183.1	113.9	130.4	187.6

There were large variations in floristic composition between PF and LF (Tables 9-10). In PF there were 383 species, represented by a combined total of 2421 individuals. The mean species richness per 1-ha plot was 180 (range 160-196), the mean number of individuals was 605 (range 571-644), mean basal area was 45.8 m^2/ha (range 34.7-53.5). In LF-5, there were 408 species, represented by a combined total of 2003 individuals. The mean species richness per 1-ha plot was 178 (range 165-193), the mean number of individuals was 501 (range 452-561), and the mean basal area was 28.5 m^2/ha (range 25.6-33.5). In LF-10, there were 384 species, represented by 2004 individuals. The mean species richness per 1-ha plot was 166 (range 157-175), mean number of individuals was 501 (range 437-536), mean basal area was 32.6 m^2/ha (range 28.9-35.3). In LF-30 there were 404 species represented by 2306 individuals. The mean species richness per 1-ha plot was 179 (range 162-197), mean number of individuals was 577 (range 558-616), mean basal area was 46.9 m^2/ha (range 40.9-53.4).

Shorea parvifolia Dyer had a prominence in PF and LF-5 with basal area values of 10.3 m^2/4ha and 6.0 m^2/4 ha, respectively (Table 11). In LF-10 and LF-30, non-dipterocarp species, namely *Elateriospermum tapos* Blume and *Heritiera simplicifolia* (Mast.) Kosterm had the largest basal areas of 6.1 m^2/4 ha and 3.6 m^2/4 ha, respectively.

The Dipterocarpaceae family had the highest basal area in all treatments: a total of 109.2 m^2 /4 ha in PF, 36.7 m^2 /4 ha in LF-5, 31.8 m^2 /4 ha in LF-10 and 72.2 m^2 /4 ha in LF-30 (Table 12).

Dipterocarpaceae and Euphorbiaceae were the two most species-rich families across all plots (Table 12); the number of species for Dipterocarpaceae was 84 across all 16 plots (Table 13). Other families, such as the pan-tropical Annonaceae, Euphorbiaceae, Moraceae, Myrtaceae, Rubiaceae, and Anacardiaceae, Burseraceae, Ebenaceae, Leguminosae, Sapotaceae, and Myristicaceae are known to be abundant and were recorded from all plots (Table 12). The most widespread species were all Dipterocarpaceae: *Parashorea malaanonan*, *Shorea agamii*, *S. atrinervosa*, *S. hopeifolia*, *S. johorensis*, *S. leprosula*, *S. macroptera*, *S. ovalis*, *S. parvifolia*, *S. pauciflora*, and *S. pinanga* were present in all plots (Table 13). Our finding of the Dipterocarpaceae from PF, LF-5, LF-10 and LF-30 were 46, 45, 35, and 43 species respectively (Table 12).

Across all plots and treatments, *Shorea parvifolia* Dyer, *S. pinanga* Scheff and *S. macroptera* Dyer were the dominant species in the Dipterocarpaceae family with total basal areas of 34.4 m^2 /16 ha, 16.2 m^2 /16 ha and 13.8 m^2 /16 ha respectively.

Table 10. The summary of the number of tree species (dbh ≥ 10 cm), number of stems, basal area, Shannon-Weiner diversity (H) and equitability (E) index values in PF, LF-5, LF-10, and LF-30, in the Bulungan Research Forest, East Kalimantan.

Treatment	Plot	Number of tree species	Number of stems	Basal area (m^2)	H	E
PF	1	196	635	44.2	2.004	0.874
	2	160	571	34.7	1.963	0.891
	3	175	571	53.5	2.036	0.908

Treatment	Plot	Number of tree species	Number of stems	Basal area (m^2)	H	E
	4	187	644	50.7	2.020	0.889
Total		**383**	**2421**	**183.1**		
Average (1 Ha)		**180**	**605**	**45.8**	**2.006**	**0.891**
LF-5	1	165	452	27.2	2.060	0.929
	2	174	468	25.6	2.036	0.909
	3	193	522	27.7	2.173	0.951
	4	178	561	33.5	1.995	0.887
Total		**408**	**2003**	**114.0**		
Average (1 Ha)		**178**	**501**	**28.5**	**2.066**	**0.919**
LF-10	1	173	437	35.3	2.012	0.899
	2	157	536	28.9	1.826	0.832
	3	160	504	32.1	1.786	0.811
	4	175	527	34.1	1.953	0.871
Total		**384**	**2004**	**130.4**		
Average (1 Ha)		**166**	**501**	**32.6**	**1.894**	**0.853**
LF-30	1	162	567	49.6	2.004	0.907
	2	185	558	43.7	1.988	0.877
	3	197	616	53.4	2.036	0.887
	4	170	565	40.9	1.962	0.879
Total		**404**	**2306**	**187.6**		
Average (1 Ha)		**179**	**577**	**46.9**	**1.998**	**0.888**
Grand total (16 Ha)		**914**	**8734**	**615.1**		

Table 11. Fifteen leading tree species in PF, LF-5, LF-10 and LF-30, based on basal area over four 1-ha plots.

PF		LF-5		LF-10		LF-30	
Species	BA (m^2)	Species	BA (m^2)	Species	BA (m^2)	Species	BA (m^2)
Shorea parvifolia Dyer	10.27	*Shorea parvifolia* Dyer	6.01	*Elateriospermum tapos* Blume	6.08	*Heritiera simplicifolia* (Mast.) Kosterm	3.56
Shorea macroptera Dyer	5.62	*Alstonia spathulata* Blume	4.31	*Koompassia excelsa* Taub.	5.85	*Shorea beccarii* Dyer ex Brandis	3.46
Shorea pauciflora King	5.56	*Parashorea malaanonan* Merrill	3.37	*Eusideroxylon zwageri* Teijsm	5.84	*Dipterocarpus pachyphyllus* Meyer	3.28
Shorea johorensis Foxworthy	2.58	*Dipterocarpus stellatus* Vesque	3.30	*Macaranga pearsonii* Merri*ll*	5.46	*Shorea pinanga* Scheff.	3.12
Dryobalanops lanceolata Burck	2.49	*Dipterocarpus lowii* Hook. f.	3.25	*Shorea pinanga* Scheff.	4.98	*Koompassia malaccensis* Maing.	2.82
Shorea cf. *obovoidea* van Slooten	2.44	*Syzygium* sp.	2.47	*Hydnocarpus* sp.1	4.76	*Macaranga hypoleuca* Muell. Arg.	2.72
Shorea parvistipulata (Heim) Symington	2.41	*Tetramerista glabra* Miq.	2.26	*Shorea parvifolia* Dyer	3.32	*Shorea angustifolia* P. S. Ashton	2.56
Shorea sp.	2.21	*Shorea macroptera* Dyer	2.17	*Macaranga hypoleuca* Muell. Arg.	2.95	*Pentace* sp. 2	2.43
Mangifera swintoniodes Kosterm	2.19	*Shorea* sp.	1.78	*Shorea sp.1*	2.78	*Shorea parvifolia Dyer*	2.36
Shorea hopeifolia (Heim) Symington	2.19	*Shorea ovalis* Blume	1.46	*Artocarpus lanceifolia* Roxb.	2.30	*Shorea agamii* P. S. Ashton	2.05
Shorea pinanga Scheff.	1.97	*Shorea johorensis* Foxworthy	1.36	*Santiria laevigata* Blume	2.25	*Dialium kunstleri* Prain	1.98
Dipterocarpus eurynchus Miq.	1.73	*Sindora leiocarpa* Baker ex K.Heyne	1.28	*Dipterocarpus* sp.1	1.72	*Artocarpus lanceifolia* Roxb.	1.94
Shorea maxwelliana King	1.69	*Calophyllum cf. lowii* Planch. & Triana	1.28	*Pometia pinnata* G.Forst.	1.69	*Hopea semicuneata* Symington	1.91
Parashorea malaanonan Merrill	1.58	Unidentified sp 4	1.24	*Shorea ovalis* Blume	1.51	*Vatica* sp. 1	1.82
Parashorea parvifolia Wyatt-Smith ex P. S. Ashton	1.53	*Shorea elliptica* Meij*er*	1.20	*Shorea atrinervosa* Symington	1.44	*Irvingia malayana* Oliver	1.71

Table 12. The fifteen commonest families based on the number of tree species, number of stems and basal area over four 1-ha plots in each of PF, LF-5, LF-10 and LF-30.

Treatment	Dipt.	Euph.	Myrist.	Anac.	Burse.	Myr.	Eben.	Leg.	Sapot.	Anno.	Morac.	Polygal.	Gutti.	Fag.	Laurac.
PF															
Number of species	46	47	22	9	14	15	16	10	11	14	11	9	14	11	16
Number of trees	758	301	158	136	104	93	114	43	59	54	47	55	35	34	27
Basal area (m^2)	109.15	9.6	4.74	7.5	5.53	5.64	3.11	6.23	2.87	1.33	2.89	1.07	1.1	2.65	1.07
LF-5															
Number of species	45	56	23	13	14	16	12	13	16	14	7	5	13	13	23
Number of trees	360	318	149	90	93	105	68	46	67	55	32	26	61	45	63
Basal area (m^2)	36.7	7.58	4.69	4.15	4.43	6.1	1.83	5.99	3.65	1.74	1.68	0.72	2.81	2.77	2.18
LF-10															
Number of species	35	53	21	12	12	14	12	10	10	21	12	5	12	8	22
Number of trees	279	775	93	32	52	42	57	52	54	57	63	16	21	17	58
Basal area (m^2)	31.81	26.77	3.03	1.87	4.88	3.06	2.29	13.38	1.23	1.69	4.3	0.67	0.87	2.47	9.56
LF-30															
Number of species	43	48	22	16	17	12	14	14	10	17	19	11	10	10	16
Number of trees	632	439	127	45	80	37	69	80	86	69	92	24	20	18	63
Basal area (m^2)	72.15	18.35	4.9	4.48	5.22	1.89	2.5	14.67	3.38	2.4	6.78	1.12	0.51	1.21	6.42
Total															
Number of species	84	108	47	32	26	35	33	25	28	39	27	17	30	26	54
Number of trees	2029	1833	527	303	329	277	308	221	266	235	234	121	137	114	211
Basal area (m^2)	249.81	62.29	17.36	17.99	20.07	16.69	9.73	40.27	11.14	7.15	15.64	3.57	5.28	9.1	19.25

Table 13. The occurrence of Dipterocarpaceae species in each of PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

No.	Species	N	BA (m^2)	PF	LF-5	LF-10	LF-30
1	*Anisoptera costata* Korth.	4	1.36	+	+	+	-
2	*Dipterocarpus cornutus* Dyer	1	0.02	-	-	-	+
3	*Dipterocarpus crinitus* Dyer	15	2.01	+	-	-	+
4	*Dipterocarpus elongatus* Korth.	4	0.15	+	+	-	-
5	*Dipterocarpus eurynchus* Miq.	38	5.94	+	-	+	+
6	*Dipterocarpus gracilis* Blume	11	1.72	+	-	-	-
7	*Dipterocarpus humeratus* van Slooten	17	2.13	-	-	+	+
8	*Dipterocarpus lowii* Hook. f.	14	3.70	-	+	-	-
9	*Dipterocarpus pachyphyllus* Meyer	17	6.20	+	-	-	+
10	*Dipterocarpus stellatus* Vesque	35	4.44	+	+	+	-
11	*Dipterocarpus tempehes* van Slooten	1	0.01	-	-	+	-
12	*Dipterocarpus verrucosus* Foxworthy ex. v. Slooten	2	0.24	+	-	+	-
13	*Dipterocarpus* sp.	8	0.65	+	-	+	+
14	*Dipterocarpus* sp.1	21	2.86	-	-	+	+
15	*Dipterocarpus* sp. 2	4	0.58	-	-	-	+
16	*Dryobalanops lanceolata* Burck	47	6.35	+	-	+	+
17	*Hopea cernua* Teijsm. & Binn.	2	0.23	-	-	+	-
18	*Hopea dryobalanoides* Miq.	93	1.60	-	+	+	+
19	*Hopea ferruginea* Parijs	130	3.01	+	+	-	-
20	*Hopea mengerawan* Miq.	8	0.11	+	-	-	-
21	*Hopea* cf. *obovoidea* Sloot.	1	0.01	+	-	-	-
22	*Hopea semicuneata* Symington	10	3.58	-	-	-	+
23	*Hopea* sp.	2	0.21	+	+	-	-
24	cf. *Hopea* sp.	8	0.78	-	-	+	+
25	*Hopea* sp. 1	2	0.08	-	-	-	+
26	*Parashorea lucida* Kurz	4	0.75	-	-	-	+
27	*Parashorea malaanonan* Merrill	111	10.22	+	+	+	+
28	*Parashorea parvifolia* Wyatt-Smith ex P. S. Ashton	16	2.81	+	+	-	-
29	*Parashorea tomentella* (Symington) Meijer	5	0.24	-	-	+	-
30	*Parashorea* sp. 1	1	0.10	-	+	-	-
31	*Shorea agamii* P. S. Ashton	36	7.54	+	+	+	+
32	*Shorea* cf. *almon* Foxworthy	1	0.01	-	-	+	-
33	*Shorea angustifolia* P. S. Ashton	102	7.41	+	-	-	+
34	*Shorea atrinervosa* Symington	17	7.35	+	+	+	+
35	*Shorea* cf. *atrinervosa* Symington	9	0.18	-	+	+	-
36	*Shorea beccarii* Dyer ex Brandis	83	9.30	+	+	-	+
37	*Shorea brunnescens* P. S. Ashton	12	0.47	-	+	-	-
38	*Shorea elliptica* Meijer	6	3.18	+	+	-	-
39	*Shorea faguetiana* Heim	10	1.34	+	-	-	-
40	*Shorea fallax* Meijer	11	1.28	-	+	-	-
41	*Shorea hopeifolia* (Heim) Symington	20	4.49	+	+	+	+
42	*Shorea inappendiculata* Burck	6	0.83	+	-	+	-
43	*Shorea johorensis* Foxworthy	57	10.67	+	+	+	+
44	*Shorea laevifolia* (Parijs) Endert	1	0.03	-	+	-	-
45	*Shorea lamellata* Foxworthy	3	0.21	-	-	-	+
46	*Shorea leprosula* Miq.	28	4.82	+	+	+	+

Table 13. Continued

No.	Species	N	BA (m2)	PF	LF-5	LF-10	LF-30
47	*Shorea macrophylla* (de Vriese) P. S. Ashton	1	0.16	+	-	-	-
48	*Shorea macroptera* Dyer	77	13.83	+	+	+	+
49	*Shorea malaononan* Blume	2	0.27	-	+	-	-
50	*Shorea maxwelliana* King	12	3.76	+	+	-	-
51	*Shorea* cf. *maxwelliana* King	7	0.42	+	+	-	-
52	*Shorea multiflora* (Burck) Symington	14	1.06	-	-	+	+
53	*Shorea* cf. *obovoidea* van Slooten	36	4.47	+	-	-	-
54	*Shorea ochracea* Symington	3	0.03	-	+	-	-
55	*Shorea ovalis* Blume	46	7.21	+	+	+	+
56	*Shorea* cf. *ovalis* Blume	2	0.57	-	+	+	-
57	*Shorea parvifolia* Dyer	265	34.42	+	+	+	+
58	*Shorea parvistipulata* Heim	26	6.58	+	-	+	+
59	*Shorea patoienis* P. S. Ashton	2	0.02	-	-	-	+
60	*Shorea pauciflora* King	35	12.06	+	+	+	+
61	*Shorea pinanga* Scheff.	88	16.17	+	+	+	+
62	*Shorea seminis* v. Slooten	3	0.11	+	-	-	-
63	*Shorea smithiana* Symington	2	0.03	-	-	-	+
64	*Shorea venulosa* G. H. S. Wood ex Meijer	4	0.33	-	+	-	-
65	*Shorea xanthophylla* Symington	38	1.26	+	+	-	-
66	*Shorea* sp.	30	7.53	+	+	-	+
67	*Shorea* sp. 1	10	3.94	-	+	+	-
68	*Shorea* sp. 2	20	1.56	-	-	-	+
69	*Shorea* sp. 3	6	0.06	-	+	-	-
70	*Shorea* sp. 4	2	0.12	-	-	-	+
71	*Shorea* sp. 5	7	1.38	-	-	-	+
72	*Shorea* sp. 6	1	0.01	-	+	-	-
73	*Vatica albiramis* v. Slooten	18	0.46	+	+	-	-
74	*Vatica granulata* v. Slooten	45	0.54	+	+	-	+
75	*Vatica micrantha* v. Slooten	30	1.89	-	-	-	+
76	*Vatica nitens* King	1	0.03	-	-	-	+
77	*Vatica oblongifolia* Hook.f.	17	1.09	+	+	+	-
78	*Vatica pauciflora* Blume	1	0.03	-	+	-	-
79	*Vatica rassak* Blume	3	0.08	+	+	-	-
80	*Vatica sarawakensis* Heim	5	0.17	-	-	+	+
81	*Vatica umbonata* Burck	51	1.28	+	-	+	+
82	*Vatica vinosa* P.S. Ashton	30	1.53	+	+	-	-
83	*Vatica* sp.	6	0.30	+	+	-	+
84	*Vatica* sp. 1	49	3.85	-	+	+	+

The impact of logging on species numbers, tree densities and basal area

Logging significantly affected the number of trees and the basal areas per plot, but not the number of species (Table 14).

Table 14. Mean number of species, individual trees ≥ 10 cm dbh, and basal area in PF, LF-5, LF-10, and LF-30. Identical letters indicate no statistically significant differences among treatments at p≥ 0.05.

Treatment	N species/ha	N trees/ha	BA (m^2/ha)
PF	180a	605a	45.8a
LF-5	178a	501b	28.5b
LF-10	166a	501b	32.6b
LF-30	179a	577ab	46.9a
p-value	0.4029	0.0095	0.0007

The number of trees in LF-5 and LF-10 was significantly lower than in PF. The basal area in PF and LF-30 was significantly higher than the basal area in LF-5 and LF-10. PF had the highest mean number of species (180/ha) and number of trees (605/ha), while LF-30 had the highest basal area of 46.9 m^2/ha, but not significantly different from PF.

The comparison of the number of species and individual trees, and basal area for the Dipterocarpaceae family showed that in the logged plots their values were lower than in PF plots (Table 15). PF had the highest mean number of species per ha (28), number of trees (190) and basal area (27 m^2/ha).

There were significant differences within the logging treatments. LF-30 had significantly higher values for dipterocarp species richness than either LF-5 or LF-10 (26/ha vs. 15 and 20), number of individuals (158/ha vs. 70 and 91.5) and basal area (18 m^2/ha vs. 7.9 and 9.3) (Table 15).

Table 15. Mean values of species richness, number of individuals and basal area for Dipterocarpaceae in four logging treatments. Significant differences ($p \leq 0.05$) among treatments are indicated by a different letter after the mean value.

Treatment	N species/ha	N trees/ha	BA (m^2/ha)
PF	28a	190a	27a
LF-5	20b	91.5bc	9.3c
LF-10	15b	70c	7.9c
LF-30	26ab	158ab	18b
p-value	0.0037	0.0038	0.0002

The mean basal area of non-dipterocarp trees was highest in LF-30 (significantly higher than that in PF and LF-5); means were not different for the number of species and number of trees for non-dipterocarps (Table 16).

Table 16. Mean values of species richness, number of individuals and basal area for trees belonging to families other than Dipterocarpaceae in four logging treatments. Significant differences among treatments are indicated by a different letter after the mean value.

Treatment	N species/ha	N trees/ha	BA (m^2/ha)
PF	151a	416a	18.5b
LF-5	161.7a	409.7a	19.15b
LF-10	152a	433.5a	24.64ab
LF-30	152a	419a	28.86a
p-value	0.6326	0.9450	0.0124

Effect of logging on the values Shannon-Weiner diversity index

The value of the diversity index was significantly higher in LF-5 (2.07) than in LF-10 (1.89), but neither value differed from either PF or LF-30 (Table 17). The higher value of H after logging may be explained by the increase in secondary forest species. The decrease in LF-10 perhaps points (together with the high volume of lying dead wood) to a particularly heavy-impact logging operation.

Table 17. Mean values of Shannon-Weiner diversity index (H) and equitability values (E) in four logging treatments. Significant differences among treatments are indicated by different letter after the mean value.

Treatment		
	H	E
PF	2.00ab	0.89ab
LF-5	2.07a	0.92a
LF-10	1.89b	0.85b
LF-30	1.99ab	0.89ab
p-value	0.0414	0.0435

The value of the diversity index was not affected significantly by stem densities differential on plots, but by the differential of number of species on plots (Table 18). It can be concluded that the differences in species richness is due to the sampling artefact.

Table 18. Correlation between Shannon-Weiner diversity index (H), number of species (N species/ha) and stem density (N trees/ha) among four forest types.

	H
H	-
N species/ha	0.61*
N trees/ha	0.02ns

Note : * = significant at 5% level; ns = not significant at 1% and 5% levels

Diameter class distribution

The diameter class distribution of trees with dbh ≥ 10 cm (Table 19) showed more or less a typical size class graph of an undisturbed primary forest. Most trees were less than 30 cm dbh (79.5 %), with 62.4% in the 10-20 cm and 17.08 % in the 20.1-30 cm size classes.

Table 19. Diameter class distribution of trees ≥ 10 cm dbh in each of PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

Treatment	Plot	dbh size class (cm)										
		10-20	20.1-30	30.1-40	40.1-50	50.1-60	60.1-70	70.1-80	80.1-90	90.1-100	>100	Total
PF	1	403	109	55	17	22	6	7	3	4	9	635
	2	391	82	39	19	15	9	1	2	9	4	571
	3	331	116	36	29	16	13	6	9	1	14	571
	4	366	119	62	38	23	9	6	8	4	9	644
Total		**1491**	**426**	**192**	**103**	**76**	**37**	**20**	**22**	**18**	**36**	**2421**
Percent of total (%)		**61.59**	**17.60**	**7.93**	**4.25**	**3.14**	**1.53**	**0.83**	**0.91**	**0.74**	**1.49**	
LF-5	1	301	59	37	21	13	9	3	4	4	1	452
	2	303	87	33	24	8	1	5	2	1	4	468
	3	315	111	42	21	19	6	4	3	1	0	522
	4	373	91	41	22	15	6	8	2	1	2	561
Total		**1292**	**348**	**153**	**88**	**55**	**22**	**20**	**11**	**7**	**7**	**2003**
Percent of total (%)		**64.50**	**17.37**	**7.64**	**4.39**	**2.75**	**1.10**	**1.00**	**0.55**	**0.35**	**0.35**	
LF-10	1	269	77	40	24	5	3	5	4	2	8	437
	2	372	77	35	22	13	6	4	3	2	2	536
	3	322	83	30	27	18	13	4	2	2	3	504
	4	358	85	34	20	14	6	1	1	1	7	527
Total		**1321**	**322**	**139**	**93**	**50**	**28**	**14**	**10**	**7**	**20**	**2004**
Percent of total (%)		**65.92**	**16.07**	**6.94**	**4.64**	**2.50**	**1.40**	**0.70**	**0.50**	**0.35**	**1.00**	
LF-30	1	318	103	57	27	27	10	4	6	5	10	567
	2	327	98	49	37	11	13	5	6	6	6	558
	3	368	89	58	45	16	12	9	2	7	10	616
	4	336	106	49	31	14	11	6	4	2	6	565
Total		**1349**	**396**	**213**	**140**	**68**	**46**	**24**	**18**	**20**	**32**	**2306**
Percent of total (%)		**58.50**	**17.17**	**9.24**	**6.07**	**2.95**	**1.99**	**1.04**	**0.78**	**0.87**	**1.39**	
Grand Total of number of individuals		**5453**	**1492**	**697**	**424**	**249**	**133**	**78**	**61**	**52**	**95**	**8734**
Percent of grand total (%)		**62.43**	**17.08**	**7.98**	**4.85**	**2.85**	**1.52**	**0.89**	**0.70**	**0.60**	**1.09**	

The impact of selective logging for trees with a dbh >50 cm was clearly visible when diameter class distribution was compared for stems ≤50.0 cm dbh and trees with a dbh >50 cm (Table 20). PF and LF-30 were similar and significantly higher for the number of stems over 50 cm dbh than LF-5 and LF-10. Logging also significantly affected the 30.1 – 40.0 cm and >100.1 cm classes. PF had the highest mean value for the >100.1 cm diameter class which is with 9 trees/ha (Table 21). LF-30 had the highest mean number of trees (53) in the 30.1 - 40.0 cm diameter class, significantly higher that LF-10 (35). Other diameter classes were not significantly affected by the logging activities.

Table 20. Mean values of the number of stems with a dbh >50 cm vs. 10-50 cm in four logging treatments. Significant differences (at p≤0.05) among treatments are indicated by different letter after mean value.

Treatment		
	N/ha (10-50 cm)	N/ha >50 cm
PF	553a	52a
LF-5	470b	31b
LF-10	469b	32b
LF-30	525ab	52a
p-value	0.0276	0.0009

Table 21. Mean values of number of stems in each of 10 cm diameter class in four logging treatments. Significant differences among treatments are indicated by different letter after the mean value.

Treatment	Diameter class (cm)					
	10.0 – 20.0	20.1 – 30.0	30.1 – 40.0	40.1 – 50.0	50.1 – 60.0	60.1 – 70.0
PF (stem/ha)	373a	107a	48.ab	26a	19a	9a
LF-5 (stem/ha)	323a	87a	38ab	22a	14a	6a
LF-10 (stem/ha)	330a	81 a	35 b	23a	13a	7a
LF-30 (stem/ha)	337a	99a	53 a	35a	17a	12a
p-value	0.2624	0.0994	0.0209	0.0619	0.3693	0.0735

Treatment	Diameter class (cm)			
	70.1 – 80.0	80.1 – 90.0	90.1 - 100.0	>100
PF (stem/ha)	5.00a	5.50a	4.50a	9.00a
LF-5 (stem/ha)	5.00a	2.75a	1.75a	2.33b
LF-10 (stem/ha)	3.50a	3.00a	2.00a	5.00ab
LF-30 (stem/ha)	6.00a	4.50a	5.00a	8.00ab
p-value	0.4492	0.3171	0.1055	0.0276

Total number of stems in PF is not significantly different with total number of stems in LF-30. However, total number of stems in PF is significantly different with total number of stems in LF-5 and LF-10. Proportion of total number of stems in LF-5, LF-10 and LF-30 compared to total number of stems in PF has an increasing trend from 82.7%, 82.8% to 95.2%. This indicated that total number of stems in the LF-30 tend to reach the total number of stems in PF (Table 22).

Table 22. Proportion of the mean values of total number of stems in primary forest and logged forest of LF-5, LF-10 and LF-30. Significant differences among treatments are indicated by different letter after the mean value.

Mean values of total number of stems in PF	Mean values of total number of stems in logged forests			Proportion (%)		
PF (A)	LF-5 (B1)	LF-10 (B2)	LF-30 (B3)	LF-5	LF-10	LF-30
605.3a	500.8b	501.0b	576.5ab	82.7	82.8	***95.2***
p-value	0.0067					

Note : Proportion (%) = ((B1 or B2 or B3) / (A)) x 100%

Abundant structure and family distribution of trees

The distribution of 10 predominant species in four different forest types can be seen in Table 23. In PF case, the most abundant species was *Mangifera swintoniodes* Kosterm (76 individuals, 3.1% of the total individuals), followed by *Hopea ferruginea* Parijs (72 individuals, 3.0%), and *Shorea parvifolia* Dyer 72 individuals, 3.0%). While in LF-05, S*horea parvifolia* Dyer (79 individuals, 3.9%) became the most abundant species, followed by *Hopea ferruginea* Parijs (58 individuals, 2.9%), and *Knema cinerea* (Poir.) Warb. (38 individuals, 1.9%). While LF-10 showed the most abundant species was pioneer species of *Macaranga pearsonii* Merrill (226 individuals, 11.3%), followed by *Macaranga hypoleuca* Muell. Arg. (142 individuals, 7.1%), and *Macaranga bancana* Muell. Arg. (103 individuals, 5.1%). All predominant species of *Macaranga* in LF-10 were not found in PF. In LF-30, the most abundant species was *Hopea dryobalanoides* (91 individuals, 3.9%), followed by *Macaranga hypoleuca* (84 individuals, 3.6%) and *Shorea beccarii* (69 individuals, 3.0%). *Hopea dryobalanoides* Miq. (91 individuals, 3.9%) was rare in PF, but became the most dominant species in LF-30. *Macaranga hypoleuca* Muell. Arg. (84 individuals, 3.6%) and three other pioneer species in LF-30 were not found in PF, but all the species, except *Shorea parvifolia* Dyer, were in rare position at LF-30.

Table 23. Distribution of 10 predominant species in four different forest types

Rank	Species Name	Abundance	Proportion (%)	Rank in PF
PF				
1	*Mangifera swintoniodes* Kosterm	76	3.1	
2	*Hopea ferruginea* Parijs	72	3.0	

Rank	Species Name	Abundance	Proportion (%)	Rank in PF
3	*Shorea parvifolia* Dyer	72	3.0	
4	*Mallotus eucaustus* Airy Shaw	69	2.9	
5	*Shorea angustifolia* P. S. Ashton	47	1.9	
6	*Shorea macroptera* Dyer	46	1.9	
7	*Vatica granulata* v. Slooten	43	1.8	
8	*Shorea pinanga* Scheff.	42	1.7	
9	*Gluta wallichii* (Hook. f.) Ding Hou	40	1.7	
10	*Knema cinerea* (Poir.) Warb.	40	1.7	
	Total individuals	2421		
LF-5				
1	*Shorea parvifolia* Dyer	79	3.9	37
2	*Hopea ferruginea* Parijs	58	2.9	2
3	*Knema cinerea* (Poir.) Warb.	38	1.9	10
4	*Syzygium* sp.	36	1.8	72
5	*Macaranga gigantea* Muell. Arg.	33	1.6	164
6	*Dipterocarpus stellatus* Vesque	29	1.4	116
7	*Teijsmanniodendron simplicifolium* Merrill.	29	1.4	382
8	*Gluta wallichii* (Hook. f.) Ding Hou	27	1.3	9
9	*Parashorea malaanonan* Merrill	27	1.3	17
10	*Mallotus penangensis* Muell. Arg.	27	1.3	31
	Total individuals	2003		
LF-10				
1	*Macaranga pearsonii* Merrill	226	11.3	*
2	*Macaranga hypoleuca* Muell. Arg.	142	7.1	*
3	*Macaranga bancana* Muell. Arg.	103	5.1	*
4	*Shorea parvifolia* Dyer	78	3.9	3
5	*Elateriospermum tapos* Blume	68	3.4	163
6	*Artocarpus lanceifolia* Roxb.	36	1.8	16
7	*Eusideroxylon zwageri* Teijsm. & Binn.	28	1.4	325
8	*Macaranga hosei* King ex Hook.f.	28	1.4	*
9	*Mallotus penangensis* Muell. Arg.	25	1.2	31
10	*Palaquium stenophyllum* H. J. Lam	24	1.2	40
	Total individuals	2004		
LF-30				
1	*Hopea dryobalanoides* Miq.	91	3.9	75
2	*Macaranga hypoleuca* Muell. Arg.	84	3.6	*
3	*Shorea beccarii* Dyer ex Brandis	69	3.0	50
4	*Shorea angustifolia* P. S. Ashton	55	2.4	5
5	*Macaranga conifera* (Zoll.) Muell. Arg.	52	2.3	*
6	*Koilodepas laevigatus* Airy Shaw	47	2.0	*
7	*Artocarpus lanceifolia* Roxb.	45	2.0	16
8	*Dialium kunstleri* Prain	39	1.7	*
9	*Vatica* sp. 1	37	1.6	159
10	*Shorea parvifolia* Dyer	36	1.6	3
	Total individuals	2306		

Note : (*) Species not found in primary forest (PF)

Table 24 shows the relative proportion of the number of species of 10 predominant tree family in primary forest, PF (A) and logged forest of LF-5 (B), LF-10 (C) and LF-30 (D). In both primary and logged forests, the most species family was Euphorbiaceae and Dipterocarpaceae (Table 24). These two made up over 32.7% of the total species in the primary forest but reduce to 22.5 – 24.7% in the logged forests. However, the most expansive family after logging in LF-5 is Lauraceae (54.3%) Followed by Meliaceae (55.6%), Lauraceae (52.9%) and Annonaceae (46.2%) in LF-10, and for the LF-30 are Meliaceae (52.0%), Lauraceae (46.7%) and Guttiferae (41.7%) (Table 24).

Table 24. Relative proportion of the number of species of 10 predominant tree family in primary forest, PF and logged forest of LF-5, LF-10 and LF-30.

Family	Species occuring in PF (A)	Species not found in PF (B)			Relative proportion (%)		
	PF	LF-5 (B1)	LF-10 (B2)	LF-30 (B3)	LF-5	LF-10	LF-30
Annonaceae	14	7	12	9	33.3	***46.2***	39.1
Burseraceae	14	5	2	7	26.3	12.5	33.3
Dipterocarpaceae	46	16	13	19	25.8	22.0	29.2
Ebenaceae	16	5	8	8	23.8	33.3	33.3
Euphorbiaceae	47	29	29	24	38.2	38.2	33.8
Guttiferae	14	6	9	10	30.0	39.1	***41.7***
Lauraceae	16	19	18	14	***54.3***	***52.9***	***46.7***
Meliaceae	12	5	15	13	29.4	***55.6***	***52.0***
Myristicaceae	22	11	10	13	33.3	31.3	37.1
Myrtaceae	15	8	10	6	34.8	40.0	28.6

Note : Relative proportion (%) = ((A) / (B1 or B2 or B3 + A)) x 100%

Coarse woody debris (CWD)

There were no statistically significant differences among logging treatments in the number of standing dead stems, their basal area or volume (Table 25). A trend was, however, discernible which showed that recent logging reduced standing CWD in comparison to PF and LF-30, a likely collateral impact of logging operations (Table 26). The basal area of ground stems was highest in LF-10, with the other treatments not being significantly different from each other (Table 27). There were no significant differences in dead ground volume (Table 27). This was caused by high variation within treatments (single extreme values in single plots: PF, LF-5 and LF-30, see Table 25). Overall, LF-10 showed a near two-fold basal area and volume of ground CWD than any of the other treatments, likely to have been caused by specific logging operation-associated factors.

Table 25. Coarse woody debris (CWD): number of stems, basal area, and volume for both standing and ground in PF, LF-5, LF-10, and LF-30 in the Bulungan Research Forest, East Kalimantan.

	Standing			Ground		
Treatment	**N**	**Basal Area (m^2/ha)**	**Volume (m^3/ha)**	**N**	**Basal Area (m^2/ha)**	**Volume (m^3/ha)**
PF						
1	26	3.7	28.6	159	9.9	64.7
2	37	3.3	18.1	66	4.6	26.2
3	21	2.3	23.4	79	4.9	33.4
4	27	4.4	41.4	59	4.4	33.1
Total	**111**	**13.7**	**111.5**	**363**	**23.8**	**157.4**
LF-5						
1	40	2.8	24.7	144	6.5	38.9
2	31	2.2	19.8	116	5.4	32.5
3	34	2.1	21.7	107	7.2	40.4
4	27	1.6	12.2	94	8.7	66.9
Total	**132**	**8.7**	**78.4**	**461**	**27.8**	**178.7**
LF-10						
1	31	1.8	13.9	45	13.3	69.3
2	27	5.7	39.4	76	20.1	90.6
3	25	2.8	20.0	89	10.8	60.0
4	22	2.2	25.6	67	11.2	80.8
Total	**105**	**12.3**	**98.9**	**277**	**55.4**	**290.7**
LF-30						
1	31	2.7	21.2	35	1.6	9.2
2	40	2.9	37.4	71	4.4	43.4
3	44	6.7	82.1	116	9.4	74.2
4	37	3.3	39.8	108	8.4	72.3
Total	**152**	**15.6**	**180.5**	**330**	**23.8**	**199.1**

Table 26. Mean values of the number of standing dead stems, their basal area and volume in four logging treatments. Significant differences ($p<0.05$) among treatments are indicated by different letters after the mean value.

Treatment	N standing dead stems	Standing basal area (m^2/ha)	Standing volume (m^3/ha)
PF	28a	3.43a	27.86a
LF-5	33a	2.18a	19.52a
LF-10	26a	3.08a	24.71a
LF-30	38a	3.89a	44.86a
p-value	0.0626	0.4837	0.2077

Table 27. Mean values of number of dead stems on the forest floor, their basal area and volume in four logging treatment. Significant differences ($p< 0.05$) among treatments are indicated by different letters after the mean value.

Treatment	N dead stems on forest floor	basal area (m^2/ha)	volume (m^3/ha)
PF	91a	5.91b	39.57a
LF-5	115a	6.89b	44.68a
LF-10	69a	13.8a	75.06a
LF-30	83a	5.93b	49.73a
p-value	0.3929	0.0382	0.1637

Height distribution

Table 28 shows that correlation value of log-normal probability plot for diameter (dbh) is higher compared to the correlation value of normal probability plot. Correlation value of log-normal probability plot for diameter (dbh) lies between 0.94 – 0.95, while correlation value of normal probability plot for diameter (dbh) is between 0.79 – 0.85. With a higher correlation value of log-normal probability plot for diameter (dbh), thus the graphic between tree diameters with tree height can be described by a log relationship.

Table 28. Correlation of probability plot for diameter (dbh) among four forest types.

Forest type	Correlation of probability plot for dbh (cm)	
	Normal	Log-normal
PF	0.81	0.95
LF-5	0.85	0.95
LF-10	0.79	0.94
LF-30	0.83	0.95

The examination of canopy heights showed that PF was of lower stature than either of the logged forest plots (Figures 23 - 26). This was confirmed by the dbh vs. height scatter plots (Figure 22).

No emergent tress (> 50 m) were recorded in PF or LF-30 (Tables 29 and 32; Figures 23 and 26) while there were a number of emergent in LF-5 and LF-10 (Tables 30 - 31; Figures 24 - 25).

In PF, the middle and upper canopy were dominated by species of the Dipterocarpaceae family such as *Vatica vinosa, Shorea macroptera, Shorea elliptica, Shorea parvifolia, Shorea pauciflora* and *Shorea atrinervosa*.

Koompassia malaccensis was dominant in the upper canopy in LF-5 (Table 30), LF-10 (Table 31) and LF-30 (Table 32). Meanwhile, emergent level in LF-10 was almost dominated by *Koompassia excelsa*. In LF-5, the emergent level was dominated by *Shorea parvifolia*.

The Dipterocarpaceae family and *Koompassia* were the main dominants in the upper canopy LF-5, LF-10 and LF-30 and emergent level in LF-5 and LF-10 (Figures 24-25).

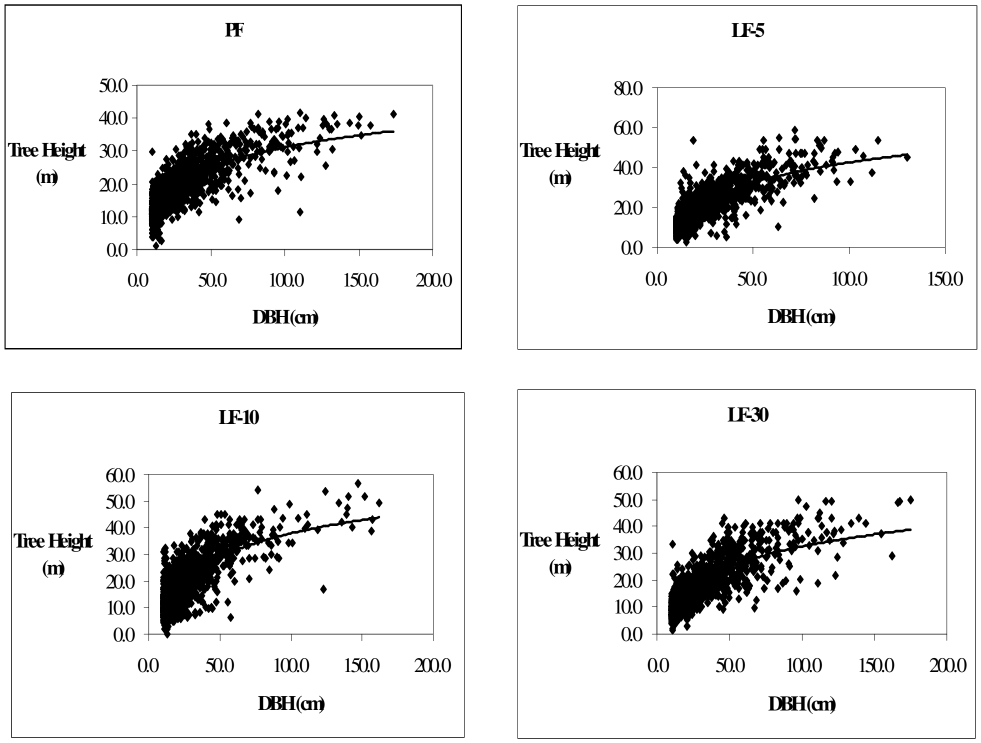

Figure 22. Diameter at breast height (dbh) vs. tree height in the four 1-ha plots in PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

Table 29. Fifteen species with the highest trees in PF in the Bulungan Research Forest, East Kalimantan.

Lower Canopy Species	Middle Canopy Species	Upper Canopy Species	Emergent Species
Ryparosa baccaureoides Sleumer	*Vatica vinosa* P.S. Ashton	*Shorea parvifolia* Dyer	not found
Pentace borneensis Pierre	*Shorea macroptera* Dyer	*Shorea pauciflora* King	not found
Ilex sp.	*Shorea elliptica* Meijer	*Shorea parvifolia* Dyer	not found
Dipterocarpus eurynchus Miq.	*Shorea* cf. *obovoidea* Sloot.	*Shorea atrinervosa* Symington	not found
Diospyros sp.	*Mangifera swintonioides* Kosterm.	*Shorea beccariana* Burck	not found
Dillenia excelsa (Jack) Gilg.	*Gymnachrantera contracta* Warb.	*Hopea ferruginea* Parijs.	not found
Coccoceras borneense J.J. Smith	*Dryobalanops lanceolata* Burck	*Shorea macroptera* Dyer	not found
Adina polycephala Benth.	*Dipterocarpus eurynchus* Miq.	*Shorea faquetiana* Heim	not found
Syzygium stictophyllum Merr. & Perry.	*Vatica vinosa* P.S. Ashton	*Shorea johorensis* Foxw.	not found
Shorea xanthophylla Symington	*Shorea parvifolia* Dyer	*Parahorea parvifolia* Wyatt-Smith ex Ashton	not found
Shorea ovalis Blume	*Shorea ovalis* Blume	*Shorea leprosula* Miq.	not found
Shorea angustifolia Ashton	*Shorea macroptera* Dyer	*Shorea johorensis* Foxw.	not found
Parashorea parvifolia Wyatt-Smith ex Ashton	*Pentace borneensis* Pierre	*Drypetes plyneura* Airy Shaw	not found
Madhuca cf. *prolixa* P.C. Yii & P. Chai	*Hopea* sp.	*Dipterocarpus eurynchus* Miq.	not found
Gymnachrantera contracta Warb.	*Garcinia rostrata* T. et B.	*Shorea parvistipulata* Heim	not found

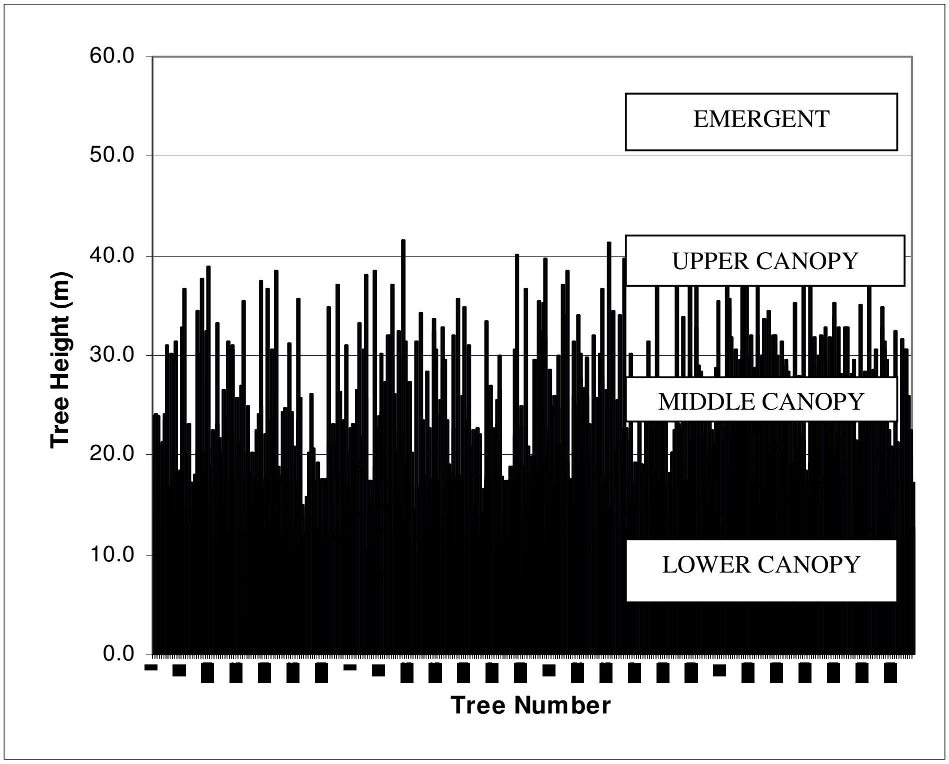

Figure 23. Simulated profile diagram constructed from data on tree heights and tree positions as approximated by the tree numbers reflecting the sequence of recording in the four 1-ha plots of PF

Table 30. Fifteen species with the highest trees in LF-5 in the Bulungan Research Forest, East Kalimantan.

Lower Canopy Species	Middle Canopy Species	Upper Canopy Species	Emergent Species
Litsea sp. 1	*Scaphium macropodum* (Miq.) Beumee ex Heyne	*Pouteria malaccensis* (C.B. Clarke) Baehni	*Shorea parvifolia* Dyer
Pternandra galeata Ridley	*Dacryodes rostrata* (Blume) H.J. Lam	*Koompasia malaccensis* Maing. ex. Benth.	*Pentace triptera* Mast.
Litsea firma Hook. F.	*Dacryodes costata* (A.W. Benn) H.J. Lam	*Barringtonia macrostachya* Kurz.	*Koordesiodendron pinnatum* Merrill
Shorea parvifolia Dyer	*Palaquium quercifolium* Burck	*Sindora leiocarpa* Baker ex K. Heyne	*Parashorea malaononan* Merrill
Dillenia exima Miq.	*Homalium grandiflorum* Benth.	*Shorea parvifolia* Dyer	*Syzygium chloranthum* (Duthie) Merrill & Perryl
Knema cinerea (Poir) Warb.	*Shorea macroptera* Dyer	*Shorea elliptica* Meijer	*Baccaurea* sp.
Dipterocarpus stellatus Vesque	*Elateriospermum tapos* Blume	*Shorea pauciflora* King	*Shorea parvifolia* Dyer
Diospyros sp.	*Xanthophyllum* sp.	*Alstonia spathulata*	*Shorea* sp.
Buchanania sessilifolia Blume	*Shorea fallax* Meijer	*Shorea fallax* Meijer	*Shorea leprosula* Miq.
Barringtonia macrostachya Kurz.	*Tetramerista glabra* Miq.	*Herritiera simplicifolia* elata Ridley	*Shorea ovalis* Blume
Magnolia gigantifolia Miq.	*Santiria griffithii* Engl.	*Diallium platysepalum* Baker	*Koompasia excelsa* (Becc.) Taub.
Scaphium macropodum Blume ex K. Heyne	*Parashorea* sp. 1	*Shorea macroptera* Dyer	
Myristica becarii Warb.	*Sarcotheca diversifolia* (Miq.) Hall.	*Calophyllum cf, lowii* Planch.& Triana	
Garcinia sp. 1	*Diospyros buxifolia* Hiern	*Shorea macroptera* Dyer	
Dialium patens Baker	*Beilschmeidia* sp. 1	*Dyera costulata* Hook. f	

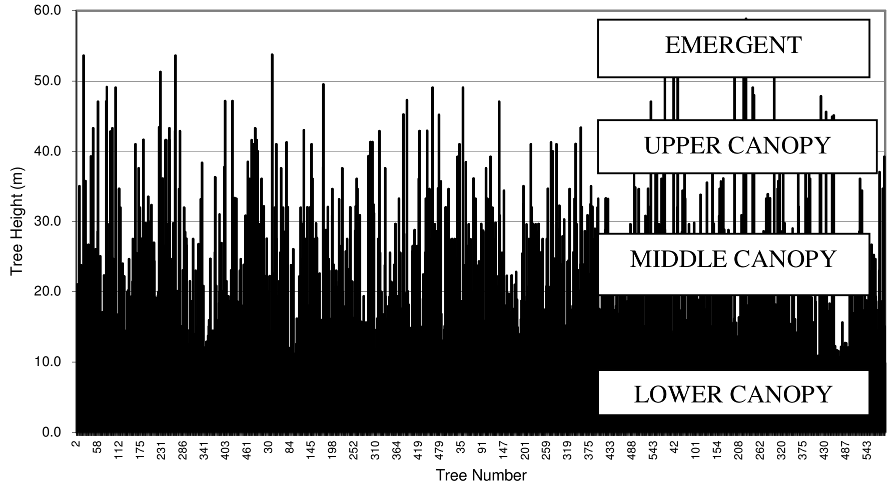

Figure 24. Simulated profile diagram constructed from data on tree heights and tree positions as approximated by the tree numbers reflecting the sequence of recording in the four 1-ha plots of LF-5

Table 31. Fifteen species with the highest trees in LF-10 in the Bulungan Research Forest, East Kalimantan.

Lower Canopy Species	**Middle Canopy Species**	**Upper Canopy Species**	**Emergent Species**
Macaranga hypoleuca (Reichb.f. & Zoll.) Muell.Arg.	*Dipterocarpus humeratus* Slooten	*Koompassia malaccensis* Maing. ex. Benth.	*Koompassia excelsa* (Becc.) Taub.
Artocarpus lanceifolius Roxb.	*Alseodaphne* sp.	*Shorea* sp.1	*Koompassia excelsa* (Becc.) Taub.
Macaranga hypoleuca (Reichb.f. & Zoll.) Muell.Arg.	*Elateriospermum tapos* Blume	*Hydnocarpus* sp.1	*Shorea atrinervosa* Symington
Macaranga pearsonii Merr.	*Dipterocarpus humeratus* Slooten	*Pometia pinnata* J.R.Forst. & G.Forst.	*Shorea* sp.1
Macaranga pearsonii Merr.	*Diospyros* sp.1	*Heritiera sumatrana* (Miq.) Kosterm.	*Koompassia excelsa* (Becc.) Taub.
Shorea parvifolia Dyer	*Dillenia excelsa* (Jack) Gilg	*Santiria laevigata* Blume	*Koompassia excelsa* (Becc.) Taub.
Paracroton pendulus (Hassk.) Airy Shaw	*Elateriospermum tapos* Blume	*Hopea cernua* Teijsn. & Binn.	
Mallotus penangensis Muell.Arg.	*Macaranga hypoleuca* (Reichb.f. & Zoll.) Muell.Arg.	*Adinandra subsessilis* Airy Show	
Macaranga pearsonii Merr.	*Aglaia* sp.5	*Dipterocarpus humeratus* Slooten	
Macaranga hypoleuca (Reichb.f. & Zoll.) Muell.Arg.	*Shorea hopeifolia* (Heim) Symington	*Shorea pinanga* Scheff.	
Pimelodendron griffithianum (Muell.Arg.) Benth.	*Pometia pinnata* J.R.Forst. & G.Forst.	*Hydnocarpus* sp.1	
Dacryodes rugosa (Blume) H.J. Lam.	*Polyalthia glauca* Boerl.	*Sindora leiocarpa* Baker ex K.Heyne	
Macaranga hosei King ex Hook.f.	*Hydnocarpus* sp.1	*Irvingia malayana* Oliv.	
Gynotroches axilaris Blume	*Horsfieldia crassifolia* (Hook.f. & Thomson) Warb.	*Dryobalanops lanceolata* Burck	
Sterculia sp.1	*Dryobalanops lanceolata* Burck	*Shorea ovalis* Blume	

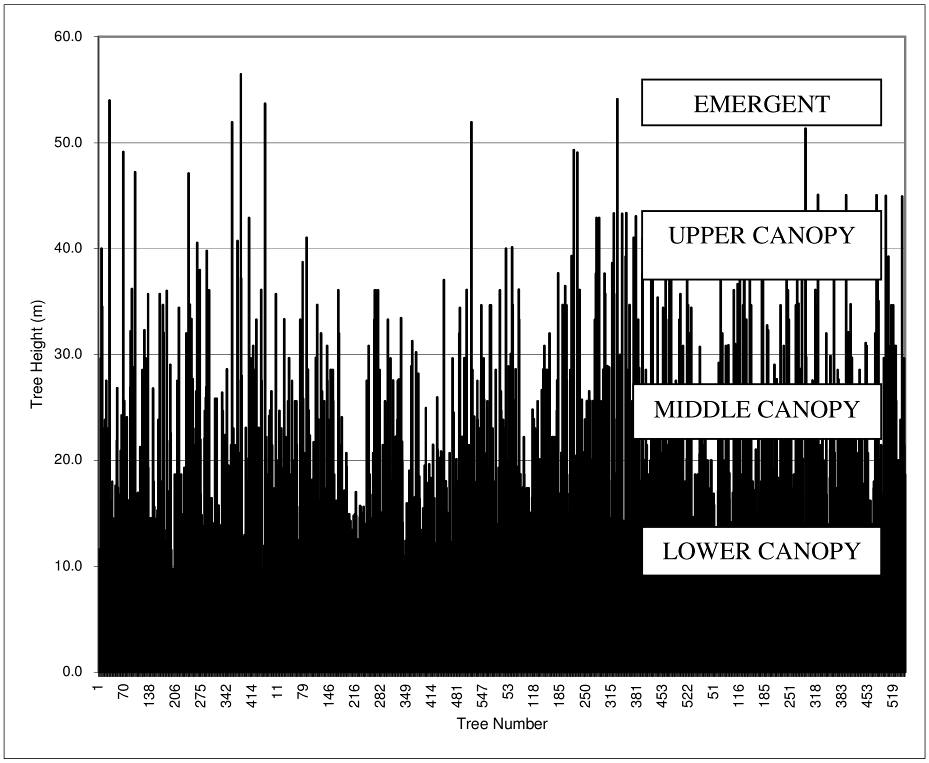

Figure 25. Simulated profile diagram constructed from data on tree heights and tree positions as approximated by the tree numbers reflecting the sequence of recording in the four 1-ha of LF-10

Table 32. Fifteen species with the highest trees in LF-30 in the Bulungan Research Forest, East Kalimantan.

Lower Canopy Species	Middle Canopy Species	Upper Canopy Species	Emergent Species
Sterculia stipulata Korth.	*Pterospermum javanicum* Jungh.	*Koompassia malaccensis* Maing. ex. Benth.	not found
Knema woodii J. Sinclair	*Caethocarpus castanocarpus* Thwaites	*Heritiera simplicifolia* (Mast.) Kosterm.	not found
Knema laurina (Blume) Warb.	*Anthocephalus chineensis* (Lamk.) A.Rich. ex Walp.	*Dipterocarpus pachyphyllus* Meijer	not found
Shorea sp.	*Sloanea javanica* (Miq.) K.Schum.	*Shorea agamii* P.S.Ashton	not found
Macaranga hypoleuca (Reichb.f. & Zoll.) Muell.Arg.	*Scaphium macropodum* (Miq.) Beumee ex Heyne	*Heritiera simplicifolia* (Mast.) Kosterm.	not found
Macaranga hypoleuca (Reichb.f. & Zoll.) Muell.Arg.	*Shorea pinanga* Scheff.	*Dipterocarpus pachyphyllus* Meijer	not found
Shorea parvifolia Dyer	*Shorea parvifolia* Dyer	*Hopea semicuneata* Symington	not found
Hopea semicuneata Symington	*Shorea leprosula* Miq.	*Hopea semicuneata* Symington	not found
Castanopsis fulva Gamble	*Shorea angustifolia* P.S.Ashton	*Shorea beccariana* Burck	not found
Xylopia malayana Hook.f. & Thomson	*Lauraceae*	*Scaphium macropodum* Beum,e ex K.Heyne	not found
Artocarpus lanceifolius Roxb.	*Parashorea malaanonan* (Blanco) Merr	*Irvingia malayana* Oliv.	not found
Artocarpus lanceifolius Roxb.	*Dipterocarpus pachyphyllus* Meijer	*Shorea pinanga* Scheff.	not found
Shorea johorensis Faxw.	*Koordersiodendron pinnatum* (Blanco) Merr.	*Shorea atrinervosa* Symington	not found
Parashorea malaanonan (Blanco) Merr	*Syzygium ochneocarpum* (Merrill) Merrill & Perry	*Dipterocarpus* sp.	not found
Macaranga gigantea (Reichb.f. & Zoll.) Muell.Arg.	*Pentace* sp. 1	*Dipterocarpus eurhynchus* Miq.	not found

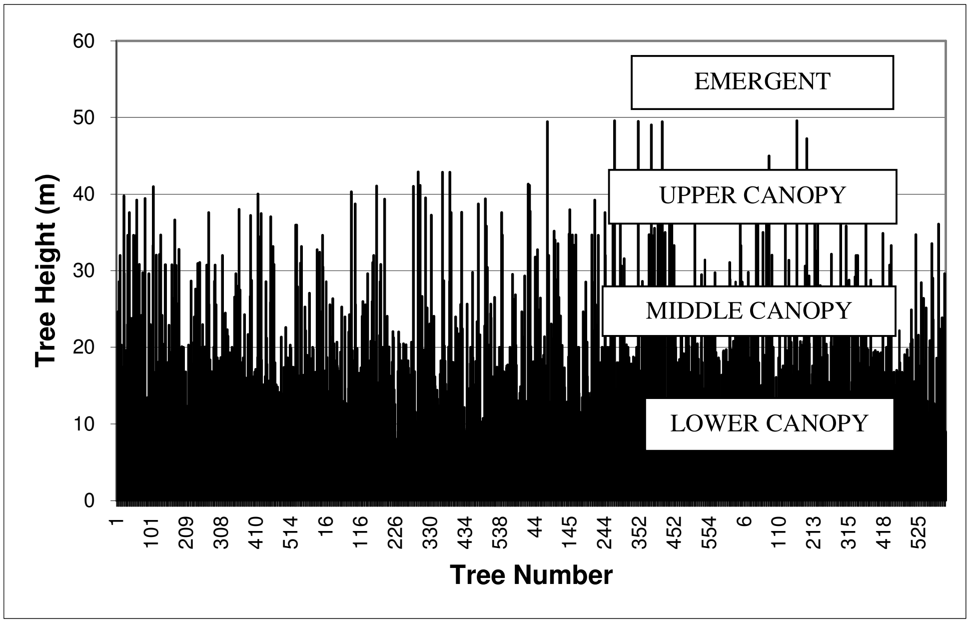

Figure 26. Simulated profile diagram constructed from data on tree heights and tree positions as approximated by the tree numbers reflecting the sequence of recording in the four 1-ha plots of LF-30

DISCUSSION

Floristic richness

In primary lowland evergreen forest the number of tree species ≥ 10 cm dbh could vary from about 60 – 150 species/ha; to over 200 - 300 species/ha in very rich areas, such as western South America and parts of Malesia (Table 33; Richards 1996). In this study, the number of species in PF ranged from 160 to 196 species/ha, with similar values in the logged plots. This is similar to values reported for 1-ha plots from elsewhere in Borneo (Table 33). However, the value of similarity in 1-ha plot was smaller than that of in 4-ha plot. The expectation to get the lower similarity within plots was found in 1 ha plots of PF while the probability to sample the similar species were higher in the 4 ha plots. The result indicated the higher similarity correlated to the ages of forest after logging (LF-05, LF-10 and LF-30) and size of sampling plots (4ha). Data in detail was shown in Table 8, related to the blooming of invasive (secondary forest species) species such *Macaranga* and other fast growing species under family Euphorbiaceae (Table 23). However, there were no correlation between distance and similarity in each pair of forest type.

As the size of the sampled contiguous areas increases the number of tree species also rises, in a somewhat logarithmic manner (compare for example the mean species richness in 1-ha plots at BRF and the species total in the 50 ha plot at Pasoh in Table 34, where a 50-fold increase in plot size resulted in a 3.7-fold increase in species numbers). The species richness in lowland evergreen rain forests is very high and the plot sizes used in most studies were not uniform (e.g. Kartawinata *et al* 1981, Sist & Saridan 1999, Riswan 1982, Wyatt-Smith 1966, Wilkie *et al* 2004), since different scientists have used different criteria (Table 34), such as a single big plot, the sum of many small plots (non-contiguous plots) and transect plots, including PSPs in this study, show no plateau or 'flattening' even at sizes of 4-5 ha (Richards 1996) when species numbers are plotted at a normal scale against sample plot areas.

The dominant family based on species numbers and basal area was Dipterocarpaceae in all plots, irrespective of treatments in this study. Other families, such as the pan-tropical Annonaceae, Euphorbiaceae, Moraceae, Myrtaceae, Rubiaceae (see e.g. Richards 1996), and Anacardiaceae, Burseraceae, Ebenaceae, Leguminosae, Sapotaceae, and Myristicaceae known to be abundant in far eastern lowland evergreen rainforest (e.g. Whitmore 1994) were recorded from all plots (Table 12). The most widespread species were all Dipterocarpaceae: *Parashorea malaanonan*, *Shorea agamii*, *S. atrinervosa*, *S. hopeifolia*, *S. johorensis*, *S. leprosula*, *S. macroptera*, *S. ovalis*, *S. parvifolia*, *S. pauciflora*, and *S. pinanga* were present in all plots (Table 13).

Selective logging is likely to affect species which have few individuals and a restricted distribution more than abundant and widely distributed ones. This may have implications for many species of the Dipterocarpaceae. Although it is the dominant family at BRF and in Borneo in general, many of its species are local, with a restricted distribution (Slik *et al.* 2002) and as a result may be sensitive to logging. At BRF, 22 species of Dipterocarpaceae out of a total of 66 in PF and LF-30 were recorded as far apart as distance of about 80 km (Table 13). Our finding of the Dipterocarpaceae from PF, LF-5, LF-10 and LF-30 were 46, 45, 35, and 43 species respectively (Table 12).

Table 24 shown that, although the basal area of dipterocarp trees has recovered in the logged forest, but the relative proportion of the number of species of predominant tree family indicates that regeneration has not been occurs in 30 years after logging, indicates that such regeneration seldom occurs or often ends in failure.

The tree species compositions differ among forest types, as it was shown in mean value of similarity index for all pairs were 0.215 (for Jaccard index) and 0.353 (for Sorensen index). The low values for similarities among forest types were most probably caused by low numbers of species shared between each forest type (Table 8). Our study in primary forest and logged forest found that similarity value among forest type dependent tree diversity (Table 8 and 10). Low species similarity between forest types followed by low in species diversity (H' = 1.894 to 2.066).

The logging operation causes a decrease in canopy cover of the forest and eventually a higher density of understorey vegetation. In general, an increase in the density of understorey vegetation leads to higher abundance of *Macaranga* in forests (Kartawinata *et al*. 1981). Such changes provide newly available light resources source for understorey plant, and can distinctly influence species composition (Whitmore, 1990). Since there are no data of the original plant community in the logged forests prior to logging, we cannot confirm that differences of the species composition between primary and logged forests are caused by logging. However logging may changed the species compositions in the genera level. It was indicated by the increase of the invasive species in the logged forest (Table 23) such as *Macaranga* spp. in the older logged forest. Our samples showed that *Mangifera swintoniodes* Kosterm, was the most abundant species in the primary forest, but was rare or absent in the logged forests (Table 23). On the other hand, *Macaranga pearsonii* Merrill, *Macaranga pearsonii* Merrill and *Hopea dryobalanoides* Miq. were rare in the primary forest but became dominant in the logged forests. *Macaranga* spp are among the fast growing species once the canopy open (Whitmore 1990). Furthermore, these species such as *Macaranga gigantea* Muell. Arg., *Macaranga pearsonii* Merrill and *Macaranga hypoleuca* Muell. Arg were highly abundant and frequent in the logged forests. The species is known to occur in large numbers in highly abundant and frequent species in the logged forests as it was shown in LF-10 and LF-30 (Table 23). These suggest that *Macaranga* spp. may favor open habitat and may be a specialist for disturbed forest species (Richards 1996). Based on these differences of dominance structure between primary and logged forests, even if some part of the variability of species composition between the forests is a consequence of differences in the original plant community, we suspect that the main differences in species composition between the forest types were related to lost of the canopy, changing the habitat structure for the plant species composition. These studies showed that species richness in selectively logged forest was not changed from that in primary forest (Table 14) but the species composition was changed because the proportion of open-habitat species increased in the community of logged forest (Table 23).

Logging was associated with a significant decrease in canopy cover and an increase in understorey vegetation density relative to primary forest. Our study showed that selective logging operation in primary forest might not dramatically decrease total species number and overall abundance of plat. However, the operation may influence the species composition and dominance structure of the plant community, accompanied by an increase of abundant of shrub-layer species such as *Macaranga*. The canopy opening caused the establishment of exclusive territories of dominant species that sometimes lead to the structural simplification of the remainder of the plant community. *Macaranga* spp. had become highly dominant among the plant community in the logged forest (Table 23). We suspect that exclusive territories of this genera appeared in the logged forest (LF-10 and LF-30) and this may be a reason that plant diversity and composition became simplified.

During succession after logging, pioneer trees reach successively larger diameter classes. In addition, some light demanding, non-pioneer tree species may exhibit higher growth rates after logging. Differential species response to disturbance can result in differences in tree composition within tree diameter classes as was shown by Newbery *et al.* (1996).

Although commercial logging operations in East Kalimantan have been increasing since the late 1960s (Kartawinata *et al.* 1981), the effects of logging related disturbance on tree diversity are largely under documented (Cannon *et al.* 1998). It is reasonable to assume that there exists a threshold where logging mediated forest disturbance increases tree species diversity by allowing the recruitment of light-demanding species, whilst maintaining the existing species pool (L. Nagy 2005, pers. comm.). This may have accounted for the higher tree species richness (dbh > 20 cm) 8 years after logging than in primary forest in West Kalimantan forest as has been reported by Cannon *et al.* (1998). Their results, however, have been criticized because of their small plot size and short time used after logging Sheil *et al.* (1998). Beyond a threshold, where a loss of the local species pool occurs and is not compensated for by the recruitment of pioneer species, a decrease in species diversity can be expected. The data from our study showed no apparent species number decreases after logging when compared with unlogged primary forest. Even if species richness was not statistically different among treatments, there was an indication of lower richness in LF-10 than in the others. This was confirmed by the H and E values (Table 17), which showed that diversity and equitability in LF-5 was higher than in LF-10. Dipterocarpaceae and Euphorbiaceae families were dominant in all plots (Table 12) where the pioneer species of *Macaranga* belongs to the Euphorbiaceae. Of the 15 species which contributed most to basal area the number of Dipterocarpaceae was 14 in PF, 8 in LF-5, 6 in LF-10 and 8 in LF-30. The data from this study did not support the findings of Cannon *et al.* (1998) for Dipterocarpaceae species (Tables 10 and 12). As selective logging mainly targets commercial species of Dipterocarpaceae, the amount of Dipterocarpaceae stems found in LF-5 (53%) and LF-10 (63%), but not in LF-30 (17%), was drastically lower than in PF. The number of stems of all non-Dipterocarpaceae families were surprisingly little affected. The reduction in density of small dipterocarp trees (and saplings) in logged plots has been attributed to mortality induced by logging (Cannon *et al.* 1994), even though these trees were too small to be felled.

Table 33. Tree density and number of species recorded in one-hectare plots in South East Asian lowland rain forest plots with some additional examples from Africa and Latin America.

Locality	**Altitude m (asl)**	**Plot Size (ha)**	**Number of replicate plots**	**Mean Density (individual /ha)**	**Mean Number of species per plot per ha**	**Source**
Malinau						
PF	100	1.0	4	605	180	This study
LF-5	100	1.0	4	501	178	This study
LF-10	100	1.0	4	501	166	This study
LF-30	100	1.0	4	577	179	This study
Seturan, Malinau	100	1.0	-	759	221	Kartawinata *et al.* (pers. comm.)
Sabah						
Segaliud Lokan2	40-100	1.0	-	365	-	Kohler 2001
Brunei Belalong Ladan Andulau	250 70 60	1.0 0.96 0.96	- - -	550 480 596	231 194 256	Poulsen *et al* (1994) Davies & Becker (1996)
Serawak Gunung Mulu 1 Gunung Mulu 2	200 50	0.95 1.0	- -	778 615	>203 223	Proctor *et al* (1983) Proctor *et al* (1983)
Wanariset Sangai, Central Kalimantan	100	1.0	15	584 (+/-)	218	Wilkie *et al* (2004)
Africa						
Kade, Ghana 1	137	1.0	-	562	86	Swaine *et al* 1987
Kade, Ghana 2	130	1.0	-	541	92	Swaine *et al* 1987
Latin America						
Rio Negro, Venezuela	119	1.0	-	-	-	Swaine *et al* 1987
Manaus, Brazil	-	1.0	-	226	-	Swaine *et al* 1987

The comparison example of mean species richness in 1-ha plots at BRF and the species total in the 50 ha plot at Pasoh, Malaysia, where shown a 50-fold increase in plot size resulted in a 3.7-fold increased in species numbers (Table 34). The species richness in lowland evergreen rain forests is higher and the plot sizes used in most studies were not uniform. The species numbers in each plot is not contiguous and the transect plot are plotted at a normal scale against sample plot areas.

Table 34. Comparison of density and number of species in the present studies with those conducted in Sumatra, Malay Peninsula and Kalimantan.

Locality	Altitude	Plot Size (Ha)	Mean Density	Number of Species	Source
East Kalimantan					
	<100	3 x 4	521.3	538	Sist & Saridan (1999)
Berau	<100	0.25	680.7	28	Kartawinata
Wanariset Semboja 1	<100	1.5	541	239	(unpublished)
Wanariset Semboja 2	<100	1.6	445	209	**Kartawinata**
Lempake					
					(1981)
					Riswan (1987)
Central Kalimantan		15	584 ± 72	1298	Wilkie *et al* (2004)

Sabah					
	30	1.8	666	198	Nicholson (1965)
Sepilok RP 17	60	2 x 4	470	138	Newbery *et al* (1992)
Danum Valley					
Serawak					
	114	52	674	1083	Chai *et al* (1995)
Lambir National Park	114	0.6	462	212	Philips *et al* (1994)
Lambir 2	114	3 x 0.6	739	240	Philips *et al* (1994)
Lambir 3,4,5	264	5 x 0.6		100	Philips *et al* (1994)
Mersing			438		
Malay Peninsula					
		50		660	Kochummen *et al*
Pasoh	460-550	2	494	253	(1990)
Bukit Lagong	30	2	476.5	232	Manokaran & Swaine
Sungei Menyala					(1994)
					Manokaran & Swaine
					(1994)
North Sumatra					
	350-450	1.6	538	116	Abdulhadi *et al*
Ketambe 1	350-450	1.6	420	94	(1989)
Ketambe 2	350-450	1.6	475	127	Abdulhadi (1991)
Ketambe 3					Abdulhadi *et al.*
					(1991)

Note: Some additional information above were collected by Kartawinata 2005 (pers. comm.)

Stand structure after logging

Stand structure, or the temporary and physical distribution of trees in an area of forest (Oliver & Larson 1990) can be described by the number of trees per unit area in different diameter classes (Meyer *et al.* 1961), to which can be added age distribution (usually related to size distribution) and canopy class distribution (Daniel *et al.* 1987). A primary forest ecosystem is healthy if the structure of the stand represents different classes of diameter, and in general, all stages of growth (seedling, sapling, pole and tree). The number of trees per unit area is always greater in the smaller than in the larger diameter classes. This is because there are more trees in lower strata and because the latter include many young individuals of species that may reach the canopy when mature as well as species that will not do so. The diameter distribution in such forest follows the classical inverse-J distribution, as was also found in this study from primary forest and logged forest (cf. Table 21). Changes in structure may result from differential diameter growth over time, influenced both by natural factors and management. There was no indication of change in structure as measured by the diameter class distribution in this study (Table 21).

According to the TPTI system, the cutting and silviculture of natural production forest can be implemented if the area has a minimum number of 25 nucleus trees (seed trees) per ha. The appointed nucleus or seed trees must belong to those commercial species which are cut, and have a diameter of 20 - 50 cm. Where the density of nucleus trees is less than 25 per ha, other commercial species with diameter of > 50 cm may be enlisted as seed trees. The minimum diameter limit of trees to be cut is 50 cm, with a cutting rotation is 35 years.

According to my observation in the field, this system was not implemented properly. There were too many stems cut and there were an excessive damage to remaining stock. A grouping of desired commercial species, especially dipterocarps will open larger gaps and cause heavy damage to the area. Although on average about 14 trees are felled per ha (MacKinnon *et al.* 1996), timber cutting intensity in East Kalimantan can reach 25 trees per ha and results in 30-40% damage by skidding alone (Matius 1991). In the study area, timber cutting ranged between 8-16 trees per ha.

As the canopy becomes fully and efficiently occupied by foliage at all levels, a certain maximum production for the stand is achieved, which is a characteristic of the interaction between site and forest type, and determines the maximum yield of the stand. It is usually described in terms of the maximum basal area of the stand, and is likely to be in the order of 45-55 m^2/ha for tropical mixed forest (Assmann 1970; Alder & Synnott 1992). The basal area values in the PF (45.8 m^2/ha) and LF-

30 (46.9 m^2/ha) in this study were in that range, whilst LF-5 (28.5m^2/ha) and LF-10 (32.6 m^2/ha) had lower values (Table 10). In this study both basal areas and the number of stems with a dbh >50 cm were similar in PF and LF-30. This alone may suggest that, all other factors being equal, a 35 year cutting cycle may be sustainable. However, simulation models for the growth of dipterocarp forest suggest that a logging cycle of at least 45 years (van Gardingen *et al.* 2003) to 60 years (Huth & Ditzer 2001), preferably in combination with reduced impact logging methods, is needed for sustainable yields. If the logging cycle is less than this period of time, the forest is unlikely to show a full recovery of structure and composition to that similar to a primary forest (i.e. unlogged forest). For example, Okuda *et al.* (2003) found that 40 years after logging using the Malayan Uniform System, the basal area of dipterocarps in the regenerating forest at Pasoh (Peninsula Malaysia) was similar to that in primary forest but the canopy was significantly lower and more even due to a lack of emergent trees. This trend was not observed in this study, except in LF-30 (Figure 26).

The higher basal area of dipterocarps in the PF in this study was in line with the practice of selective logging, which primarily targets large sized commercial trees, which at first cutting are dominated by dipterocarps. The higher basal area of non-dipterocarps in the logged plots than in PF has probably arisen from the opening of the canopy after selective removal of dipterocarps which provides better growth conditions (more space and light) for remaining trees. *Alstonia spathulata* Blume, *Eusideroxylon zwageri* Teijsm, *Syzygium* sp., *Mangifera swintonioides* Kosterm, *Elateriospermum tapos* Blume, *Heritiera simplicifolia* (Mast.) Kosterm and

Koompassia excelsa Taub. are non-Dipterocarpaceae species, which had higher basal area values than another non-Dipterocarpaceae species.

Although the impact of logging on the number of trees and species is obvious, the data from LF-30 as mentioned above showed an equal basal area with PF. The data also showed that LF-30 is dominated by commercial species from the Dipterocarpaceae family. According to the TPTI system, LF-30 is mature enough for a second harvest in 5 years time as this system uses a 35 year harvest cycle.

However, the time taken for tropical forest to reach maturity through successional processes is still unknown. The absence of annual rings and differences in growth rates between PF and LF tree species make an estimation of time scale difficult. Although trees over 50 cm dbh are large enough to cut, some may be relatively young and may have never reached flowering stage, especially for dipterocarp species, which flower and fruit irregularly (Kartawinata *et al.* 1981). So, a 35 year cutting cycle may not give opportunities to many dipterocarps of sufficient girth to be harvested for the second cutting period for their reproductive contribution to future harvest regeneration.

Various estimates agree that and rate of development in forest communities as well as individual species is over 100 years. Miscalculation in managing forests will cause genetic erosion and the loss of species diversity (Ewel and Conde 1980, Jacobs 1980 *in* Kartawinata *et al.* 2001), because selective logging creams off the best trees of commercial species, especially those of dipterocarps. Residual trees which are to provide seeds for future crops are smaller and genetically inferior, and sometimes even undesirable (Blanche 1978, Ashton 1980 *in* Kartawinata *et al.* 2001). Moreover, the residual trees, saplings and seedlings of commercial dipterocarp species in logged forests usually have a lower quantity (Chapter 4; DFID and MOFEC 2000).

The number of tree species in logged forests have been reported to be lower than those in primary forest, but the standing stock may be higher and the nucleus trees present in sufficient numbers for future forest development (Gintings 1969, Tarumingkeng *et al.* 1989 *in* Kartawinata *et al.* 2001). High logging damage, including crown injuries, have negative impacts on forest recovery and hence on volume increment and the response of the stand depends on the degree of canopy opening which is related to the intensity of logging (Bertault & Sist 1995, Sist 2000 *in* Kartawinata *et al.* 2001).

So, if the government decides to conduct a second harvest of LF-30 forest many risks will be taken. Mismanagement of the forest resource will lead to the potential loss or degradation of genetic resources and the possibility that entire species, many of which are still unknown to science, might be lost forever.

Tree heights have been rarely measured (Unesco 1978), because of the difficulties of measurement and the unreliability of the data. However, the measurement of tree heights is important as changes to vertical structure may become evident through repeat measurements in multi-strata forests, for example, the loss of an emergent layer (*sensu* Whitmore 1984) after logging. In this study, height data showed an odd distribution of trees with no emergent trees in PF and LF-30, although the upper and middle canopy of PF were dominated by the Dipterocarpaceae family (Table 29). This could be because the emergents were removed in LF-30, and PF may be growing in a less fertile area (it is reasonable to assume that the concessionaires may have started logging in the best areas and then moved into the less good ones after the best were harvested). The emergent species of Dipterocarpaceae was found only in LF-5 (*Shorea parvifolia*) (Table 30) and the rest were dominated by fast growing legume species of *Koompassia excelsa* (LF-10) and in upper canopy *K. malaccenesis* (LF-5, LF-10 and LF-30) (Tables 30-32). Whitmore (1984) also reported that the emergent layer in Malaya was dominated mostly by Dipterocarpaceae and Leguminosae. He further mentioned that of the Dipterocarpaceae, *Dipterocarpus*, *Dryobalanops* and *Shorea* provide most emergents but by contrast *Hopea* and *Vatica* belong to the upper and middle canopy. *Koompassia*, *Dialium* and *Sindora* are the only species from 53 species of Leguminosae that grow large enough trees to be emergent. Slik *et al.* (2003) found Dipterocarpaceae and Euphorbiaceae as the dominant families in Kalimantan, however, in their study legumes ranked 12th among families and no legume genus occurred among the 25 most common genera, while in this study, legumes ranked 3 and 4 within 15 family dominance (Table 12).

The term coarse woody debris (CWD) is little used among forest managers in Indonesia. According to Stevens (1997), CWD is defined as: "Sound and rotting logs and stumps that provide habitat for plants, animals and insects and a source of nutrients for soil development. Material generally greater than 8-10 cm in diameter".

CWD is primarily created as a result of tree death and it persists for some time following natural disturbances or forest harvesting. CWD forms part of the dead wood cycle wherein dead wood, whether standing or down, enters and leaves the forest ecosystem (Parminter 2002).

CWD is critically important as habitat for wildlife (Snowman 2004). For example, there are twice as many species of beetles that live on dead and dying wood as there are species of mammals, birds, reptiles, and amphibians in the entire world (Snowman 2004). Decaying wood also supports a range of bryophytes and fungi. The realization of the value of CWD for biodiversity has led foresters in North America to leave patches of forest uncut within timber harvest blocks during commercial logging operations. The management of CWD in Indonesia is far from reality, although it has been identified as one of the important components of biodiversity conservation programs (Proulx & Kariz 2002). That is why the implementation of research, strategic higher level wildlife objectives and stand level wildlife objectives is important. Prescribing stand conditions and implementing the intent of landscape level wildlife objectives has implications for how harvesting and silvicultural operations are conducted (Nochol 2002). The main impact of logging on vegetation is obvious. Felling even only 10% of the trees can result in destruction to at least 55% of the other trees leaving only 35% of the forest undisturbed after logging (MacKinnon *et al.* 1996). In East Kalimantan typical figures for forest damage from logging vary from 15% to 50% (Abdulhadi *et al.* 1981 *in* MacKinnon *et al.* 1996). Wyatt-Smith & Foenander (1962) found that 30% of the logged forest was covered by the crowns and residual boles of felled trees. The amount of biomass and inputs from residual trees in tropical rain forest are poorly documented (Clark *et al.* 2002), and the causes for their variation at landscapes scales has not been studied. It appears from the present study that in the absence of logging in the long term, the amount of CWD in PF in this study is about 270 m^3/ha. CWD is a dynamic resource (Lloyd & MacMillan 2002), the various amounts of CWD in logged and unlogged forest apparently due to natural mortality (PF and LF) and in addition, that caused by human destruction (LF). Compared with old tropical forest in La Selva, Costa Rica where the average amount of standing and dead wood was 25.4 m^3/ha (Clark *et al.* 2002), the amount of CWD in PF in BRF is more than 10 fold higher.

The tree performance in the study area can be seen in Figures 27-29.

Figure 27. Pioneer species of *Macaranga gigantea* (above) and large tree of *Shorea leprosula* in plot location .

Figure 28. Large trees of *Shorea* in plot location (above) and climber Equipment used for fertile specimen collection

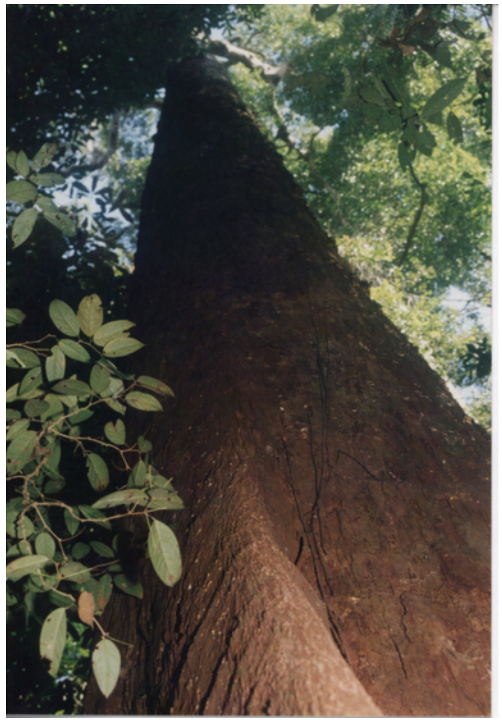

Figure 29. A typical trunk of *Sarcoteca* sp., useful fruit tree species for local people and wildlife (above) and *Shorea* trees in primary forest plot.

CHAPTER 4. REGENERATION IN UNLOGGED AND LOGGED FOREST

INTRODUCTION

Dipterocarp-rich lowland evergreen rain forest covers most of East Kalimantan Province. Past and present exploitation and destruction have decreased the area of primary forest. Most forest is now logged over, characterized by logging roads dissecting the forest and by large gaps. The rivers carry a lot of suspended material and have a muddy appearance due to land clearance and logging; grassy hills, and a patchwork of cleared agricultural fields are found along the logging roads. Only a small proportion of rainforest trees are commercially valuable and will be removed for timber. Although only a few trees per ha on average are removed from dipterocarp forest the damage to the remaining forest is remarkable (e.g. MacKinnon *et al.* 1996). The felled trees damage a considerable part of the surrounding forest including trees valuable for local community and wildlife and cause the depletion of unknown genetic resources.

Government regulations for the timber industry have been formulated through the system called the Indonesian Selective Cutting System (TPTI, see Appendix 11) to encourage a sustainable harvesting system. This system is designed to ensure that the number of good size of trees will be retained so that natural regeneration can take place. According to this system, concessionaires only undertake one cutting and must give the logged over forest a minimum of 35 years to regenerate and recover before being logged again.

This chapter compares regeneration (seedlings and saplings) in primary forest with logged over forest (LF-5, LF-10, and LF-30). The aim of this study was to evaluate if:

- current timber harvest (timber or potential timber species) practices allowed sufficient regeneration;
- timber can be harvested sustainably from lowland forest in Indonesia;
- the Indonesian Selective Cutting System is suitable to allow sustainable forest management system in Indonesia.

METHODS

Sampling design

Five sub-plots of 20 m x 20 m in each 1-ha plot (see Chapter 3 for details for plots and logging treatments), selected in a stratified random way were enumerated for saplings, with a dbh $\geq$ 2 cm and < 10 cm. Within each of the sub-plots, 10 m x 10 m areas were selected for the enumeration of seedlings. The saplings were labelled with an aluminium tag and their dbh was recorded. Seedlings (dbh <2 cm) were recorded and their height measured.

The data collected were analyzed following Mueller-Dombois & Ellenberg (1974): density is the number of individuals or species/ha; species dominance is used synonymously with the basal area of each species; and frequency was calculated as the number of plots where a species was recorded/total number of sample plots. Importance value is calculated as the total of relative density, relative frequency and relative dominance.

RESULTS

The full list of species by family and their density, relative density, frequency and basal area of each are shown in Appendices 13-72.

Seedlings

The total number of species for which seedlings were recorded within a total of 80 10 m x 10 m areas across 16 1-ha plots was 1,022 belonging to 408 genera of 111 families (Table 35). In PF there were 469 species, represented by 19,416 individuals in the 20 10 m x 10 m areas within the four 1-ha sample plots; in LF-5, 295 species and 20,256 individuals; in LF-10, 451 species with 11,158 individuals and in the LF-30 489 species and 26,351 individuals (Table 35). The number of genera in PF, LF-5, LF-10 and LF-30 were 234, 200, 266 and 237 belonging to 83, 83, 93 and 90 families, respectively (Table 35).

Table 35. Summary of the taxonomic composition of seedlings enumerated in PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

		PF	LF-5	LF-10	LF-30
Number of families		83	83	93	90
Number of genera		469	295	451	489
Number of species/0.05 ha					
	Dipterocarp	24	26	23	29
	Non-Dipterocarp	445	269	428	460
Total		469	295	451	489
Number of individuals/0.05 ha					
	Dipterocarp	11425	9629	809	10689
	Non-dipterocarp	7991	10627	10349	15662
	Total	19416	20256	11158	26351
Importance Value (%)					
	Dipterocarp	68	55	13	45
	Non-Dipterocarp	132	145	187	155
	Total	200	200	200	200

Of all the individuals 32,409 were seedlings of 48 species of Dipterocarpaceae (Table 36). Of Dipterocarpaceae recorded across all the plots, with *Hopea dryobalanoides* (13,818 seedlings in total), *Vatica micrantha* (3,340) and *Shorea parvifolia* (2,725) occurring in every plot (Table 36).

Of the fifteen leading species *Hopea dryobalanoides* had the highest importance values in PF, LF-5 and LF-30 (22.5 %, 30.9% and 13.1%, respectively). In PF-10, *Endospermum diadenum* had the highest importance value (Table 37).

The Total Species Importance Values for a Family (TSIVF) was highest for Dipterocarpaceae with 62.6 % in PF, 56.1 % in LF-5 and 47.2 % in LF-30, while Zingiberaceae was dominant in LF-10 (Table 38).

Table 36. The list of dipterocarp seedlings < 2 cm dbh recorded from PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

No.	Species	N	PF	LF-5	LF-10	LF-30
1	*Anisoptera* sp.	40	-	+	+	-
2	*Dipterocarpus crinitus* Dyer	157	-	+	-	-
3	*Dipterocarpus lowii* Hook. f.	12	-	+	-	-
4	*Dipterocarpus* sp.	288	-	+	-	+
5	*Dipterocarpus* sp.1	9	-	-	-	+
6	*Dipterocarpus* sp.2	26	-	-	-	+
7	*Dryobalanops lanceolata* Burck	1,462	+	-	+	+
8	*Hopea* cf. *rudiformis*	1	-	-	-	+
9	*Hopea dryobalanoides* Miq.	13,818	+	+	+	+
10	*Hopea* sp.	9	-	-	+	-
11	*Parashorea malaanonan* Merrill	385	+	+	+	+
12	*Parashorea* sp.	255	-	+	+	+
13	*Parashorea* sp.1	1	+	-	-	-
14	*Parashorea tomentella* (Symington) Meijer	51	+	-	-	-
15	*Shorea agamii* P. S. Ashton	82	-	-	-	+
16	*Shorea angustifolia* P. S. Ashton	1,465	+	-	-	+
17	*Shorea beccarii* Dyer ex Brandis	238	+	-	-	+
18	*Shorea* cf. *exstipulata*	3	+	-	-	-
19	*Shorea* cf. *mujogensis* P.S.Ashton	1,860	+	-	-	+
20	*Shorea* cf. *ovalis* Blume	1	-	-	-	+
21	*Shorea* cf. *venulosa*	57	-	-	+	-
22	*Shorea exstipulata*	13	+	-	-	-
23	*Shorea fallax* Meijer	36	-	+	-	-
24	*Shorea hopeifolia* (Heim) Symington	69	-	-	+	-
25	*Shorea inappendiculata* Burck	16	-	-	+	-
26	*Shorea johorensis* Foxworthy	274	+	+	+	+
27	*Shorea laevifolia* (Parijs) Endert	7	-	+	-	-
28	*Shorea leprosula* Miq.	304	+	+	+	+
29	*Shorea macrophylla* (de Vriese) P. S. Ashton	18	-	+	+	+
30	*Shorea macroptera* Dyer	542	+	+	-	+
31	*Shorea maxwelliana* King	174	+	-	-	+
32	*Shorea multiflora* (Burck) Symington	362	-	+	+	-
33	*Shorea ovalis* Blume	60	+	+	-	+
34	*Shorea parvifolia* Dyer	2,725	+	+	+	+
35	*Shorea parvistipulata* Heim	30	+	-	+	+
36	*Shorea patoienfis* P. S. Ashton	1,049	-	-	+	+
37	*Shorea pauciflora* King	154	+	-	+	+
38	*Shorea peltata* Symington	204	+	-	-	+
39	*Shorea pinanga* Scheff.	29	-	+	+	-
40	*Shorea* sp.	38	-	+	+	+
41	*Shorea* sp.1	2,265	+	+	+	+
42	*Shorea* sp.2	78	-	+	-	+
43	*Vatica granulata* v. Slooten	230	+	-	-	-
44	*Vatica micrantha* v. Slooten	3,340	+	-	-	+
45	*Vatica nitens* King	12	+	-	-	-
46	*Vatica oblongifolia* Hook.f.	4	-	-	+	-
47	*Vatica* sp.	26	-	-	+	-
48	*Vatica umbonata* Burck	131	+	-	+	+
	Total	32,409	24	20	23	29

Table 37. Fifteen leading species based on importance values of seedlings < 2 cm dbh in a four 1-ha plots in each of PF, LF-5, LF-10, and LF-30.

PF		**LF-5**		**LF-10**		**LF-30**	
Species	**IV (%)**	**Species**	**IV (%)**	**Species**	**IV (%)**	**Species**	**IV (%)**
Hopea dryobalanoides Miq.	22.48	*Hopea dryobalanoides* Miq.	30.89	*Endospermum diadenum (*Miq.) Airy Shaw	4.32	*Hopea dryobalanoides* Miq.	13.07
Shorea parvifolia Dyer	8.47	*Shorea* sp.1	7.10	*Alpinia* sp.	4.20	*Vatica micrantha* v. Slooten	10.84
Dryobalanops lanceolata Burck	7.49	*Syzygium* sp.	4.57	*Costus globosus*	3.01	*Connarus sp.*	6.89
Shorea cf. *mujogensis* P.S.Ashton	5.85	*Shorea parvifolia* Dyer	4.46	*Shorea parvifolia* Dyer	2.69	*Scaphium macropodum* Beume ex K. Heyne	4.39
Shorea angustifolia P. S. Ashton	5.60	*Macaranga bancana Muell.* Arg.	2.97	*Zingiber* sp.1	2.68	*Shorea patoienfis* P. S. Ashton	4.34
Koilodepas sp.	4.35	*Dacryodes rostrata* (Blume) H. J. Lam forma pubescens	2.80	*Cyrtandra* sp.1	2.50	*Koilodepas* sp.	3.49
Spatholobus sp.3	3.48	*Zingiber* sp.3	2.74	*Costus* sp.	2.25	*Shorea* sp.1	3.29
Vatica micrantha v. Slooten	2.86	*Artabotrys* sp.	2.63	*Plagiostachys* sp.	2.19	*Shorea cf. mujogensis* P.S.Ashton	2.93
Connarus sp.	2.61	*Gluta wallichii* (Hook. f.) Ding Hou	2.45	*Scindapsus* sp.	2.15	*Lophopetalum* sp.	2.64
Shorea macroptera Dyer	2.33	*Daemonorops* sp.	2.22	*Urticaceae*	2.08	*Mallotus dispar* (Blume) Mull.Arg	2.57
Dipterocarpus sp.	1.59	*Connarus semidecandrus* Jack	1.69	*Schindapsus* sp.	2.01	*Endospermum diadenum* (Miq.) Airy Shaw	2.12
Vatica granulata v. Slooten	1.55	*Costus* sp.	1.65	*Bauchinia* sp.	1.97	*Shorea angustifolia* P. S. Ashton	2.07
Baccaurea tetandra Muell. Arg.	1.45	*Scindapsus* sp.	1.62	*Shorea multiflora* (Burck) Symington	1.88	*Ziziphus angustifolia* (Miq.) Hatusina ex Stennis	1.60
Spatholobus sanguineus Elmer	1.40	*Pandanus* sp.	1.58	*Spatholobus hirsutus* H.Wiriadinata & J.W.A.Ridder-Numan	1.86	*Strychnos* sp.1	1.52
Scaphium macropodum Beume ex K. Heyne	1.40	*Spathoglottis* sp.	1.54	*Ziziphus angustifolia* (Miq.) Hatusina ex Stennis	1.69	*Spatholobus* sp.3	1.48

Table 38. Fifteen leading families based on Total Species Importance Value of seedlings < 2 cm diameter in four 1-ha plots per each of PF, LF-5, LF-10 and LF-30.

PF		LF-5		LF-10		LF-30	
Family	**TSIV (%)**	**Family**	**TSIV (%)**	**Family**	**TSIV (%)**	**Family**	**TSIV (%)**
Dipterocarpaceae	65.27	Dipterocarpaceae	56.08	Zingiberaceae	21.20	Dipterocarpaceae	47.17
Euphorbiaceae	19.89	Euphorbiaceae	12.88	Euphorbiaceae	20.24	Euphorbiaceae	22.26
Leguminosae	14.05	Zingiberaceae	8.17	Dipterocarpaceae	12.33	Leguminosae	9.47
Rubiaceae	9.52	Annonaceae	7.94	Rubiaceae	11.34	Connaracae	8.78
Annonaceae	6.92	Anacardiaceae	6.95	Leguminosae	11.10	Annonaceae	8.02
Connaracae	4.13	Palmae	6.46	Annonaceae	10.03	Rubiaceae	7.53
Palmae	3.99	Rubiaceae	6.40	Palmae	6.47	Sterculiaceae	6.24
Myristicaceae	3.88	Leguminosae	6.39	Araceae	6.30	Moraceae	4.76
Lauraceae	3.27	Burseraceae	4.99	Moraceae	5.87	Lauraceae	4.25
Meliaceae	2.98	Myrtacaceae	4.89	Lauraceae	4.22	Palmae	4.20
Ebenaceae	2.91	Lauraceae	4.08	Sapindaceae	3.69	Anacardiaceae	3.90
Myrtacaceae	2.82	Melastomataceae	3.57	Gesneriaceae	3.58	Celastraceae	3.61
Anacardiaceae	2.78	Meliaceae	3.31	Myristicaceae	3.55	Burseraceae	3.45
Guttiferae	2.57	Araceae	3.07	Connaracae	3.49	Myristicaceae	3.42
Polygalaceae	2.50	Myristicaceae	2.94	Rhamnaceae	3.03	Ebenaceae	3.00

Saplings

The total number of species of saplings recorded in the 80 20 m x 20 m sub-plots across all 16 plots was 802 in 241 genera and 65 families. The number of genera in PF, LF-5, LF-10 and LF-30 was 144, 172, 152 and 121, belonging to 48, 55, 56 and 46 families, respectively (Table 39). In PF, 351 species, represented by 2,565 individuals had a total basal area of 4.14 m^2/0.2 ha; in LF-5 462 species, represented by 2,553 individuals and a total basal area of 3.79 m^2/0.2 ha; in LF-10, 270 species with 1,609 individuals and with a basal area of 2.68 m^2/0.2 ha; and in LF-30 207 species with 1,153 individuals with an average of basal area 2.58 m^2/0.2 ha.

Dipterocarpaceae was the dominant family with regard to the basal area of saplings with 1.35 m^2 in PF, 0.91 m^2 in LF-5, 0.59 m^2 in LF-10 and 0.71 m^2 in LF-30 (Table 40). There were 66 species of Dipterocarpaceae recorded across all treatments (Table 41). Of those, *Shorea parvifolia* (BA = 0.525 m^2), *Vatica granulata* (0.476

m^2) and *Parashorea malaanonan* (0.144 m^2) had the highest combined total basal areas.

Fifteen leading species based on basal area of saplings in four 1-ha plots of lowland forest can be seen in Table 42. *Vatica granulata* had the highest BA in PF (0.27 m^2) followed by *Hopea ferruginea* in LF-5, *Shorea parvifolia* in LF-10 and *Hopea dryobalanoides* in LF-30 with basal areas of 0.24 m^2, 0.29 m^2 and 0.31 m^2 respectively. *Shorea parvifolia* was also the only species listed as one of the leading species in PF, LF-5, and LF-10 but not in LF-30.

Only seven Dipterocarp species occurred in all plots and 14 species out of 50 Dipterocarpaceae species occurs in both PF and LF-30 (Table 41).

Table 39. Summary of taxonomic composition of saplings enumerated in PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

		PF	LF-5	LF-10	LF-30
Families		48	55	56	46
Genera		144	172	152	121
Species (N/ 0.2 ha)					
	Dipterocarp	38	40	20	28
	Non-Dipterocarp	313	422	250	179
	Total	351	462	270	207
Saplings (N/ 0.2 ha)					
	Dipterocarp	789	615	372	316
	Non-Dipterocarp	1776	1938	1237	837
	Total	2565	2553	1609	1153
Basal Area (m^2/0.2 ha)					
	Dipterocarp	1.35	0.91	0.59	0.71
	Non-Dipterocarp	2.79	2.88	2.09	1.87
	Total	4.14	3.79	2.68	2.58
Importance Value (%)					
	Dipterocarp	76	59	53	69
	Non-Dipterocarp	224	241	247	231
	Total	300	300	300	300

Table 40. Fifteen families with the highest basal areas of saplings in PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

PF		LF-5		LF-10		LF-30	
Family	BA (m^2)	Family	BA (m^2)	Family	BA (m^2)	Family	BA (m^2)
Dipterocarpaceae	1.35	Dipterocarpaceae	0.91	Euphorbiaceae	0.64	Dipterocarpaceae	0.71
Euphorbiaceae	0.60	Euphorbiaceae	0.71	Dipterocarpaceae	0.59	Euphorbiaceae	0.37
Myristicaceae	0.24	Myrtaceae	0.36	Myristicaceae	0.15	Celastraceae	0.17
Rubiaceae	0.18	Sapotaceae	0.17	Moraceae	0.14	Myristicaceae	0.13
Ebenaceae	0.17	Myristicaceae	0.16	Meliaceae	0.11	Myrtaceae	0.11
Annonaceae	0.15	Burseraceae	0.14	Burseraceae	0.10	Burseraceae	0.10
Myrtaceae	0.14	Lauraceae	0.12	Sapindaceae	0.09	Ebenaceae	0.09
Flacourtiaceae	0.13	Ebenaceae	0.10	Verbenaceae	0.07	Moraceae	0.09
Polygalaceae	0.13	Annonaceae	0.10	Ebenaceae	0.07	Annonaceae	0.09
Burseraceae	0.13	Melastomataceae	0.09	Annonaceae	0.06	Sapotaceae	0.06
Sapotaceae	0.11	Anacardiaceae	0.08	Leguminosae	0.06	Anacardiaceae	0.05
Tiliaceae	0.08	Meliaceae	0.08	Sterculiaceae	0.06	Lauraceae	0.05
Celastraceae	0.06	Rubiaceae	0.08	Sapotaceae	0.05	Leguminosae	0.05
Lauraceae	0.06	Guttiferae	0.08	Rubiaceae	0.05	Sterculiaceae	0.04
Anacardiaceae	0.05	Moraceae	0.05	Polygalaceae	0.05	Polygalaceae	0.04

Table 41. The number of individuals and total basal area (m^2) of each dipterocarp sapling recorded from PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan.

No	Species	N	BA	PF	LF-5	LF-10	LF30
1	*Anisoptera costata* Korth.	3	0.002	+	-	+	-
2	*Dipterocarpus crinitus* Dyer	2	0.001	-	+	-	-
3	*Dipterocarpus elongatus* Korth.	7	0.013	+	-	-	-
4	*Dipterocarpus eurynchus* Miq.	32	0.059	+	-	-	-
5	*Dipterocarpus humeratus* van Slooten	2	0.001	-	-	+	-
6	*Dipterocarpus lowii* Hook. f.	8	0.021	-	+	-	-
7	*Dipterocarpus pachyphyllus* Meyer	3	0.005	+	-	-	-
8	*Dipterocarpus* sp.	21	0.044	-	+	+	+
9	*Dipterocarpus stellatus* Vesque	12	0.022	-	+	-	-
10	*Dryobalanops* elliptica	1	0.001	+	-	-	-
11	*Dryobalanops lanceolata* Burck	60	0.072	+	-	+	+
12	*Hopea cernua* Teijsm. & Binn.	19	0.025	+	-	-	-
13	*Hopea* cf. *cernua* Teijsm. & Binn.	1	0.003	-	-	-	+
14	*Hopea* cf. *rudiformis* P.S. Ashton	1	0.002	-	-	-	+
15	*Hopea dryobalanoides* Miq.	158	0.346	+	+	+	+
16	*Hopea ferruginea* Parijs	251	0.414	+	+	-	-
17	*Hopea mengerawan* Miq.	5	0.006	+	+	-	-
18	*Hopea* sp.	7	0.010	+	-	-	+
19	*Parashorea malaanonan* Merrill	78	0.144	+	+	+	+
20	*Parashorea parvifolia* Wyatt-Smith ex P. S. Ashton	1	0.002	+	-	-	-
21	*Parashorea* sp.	3	0.005	-	-	+	+
22	*Shorea agami* P. S. Ashton	18	0.025	+	+	-	+
23	*Shorea angustifolia* P. S. Ashton	31	0.059	+	-	-	+
24	*Shorea atrinervosa* Symington	5	0.008	+	+	-	-
25	*Shorea beccarii* Dyer ex Brandis	41	0.087	+	+	-	+
26	*Shorea bracteolata* Dyer.	2	0.004	-	+	-	-
27	*Shorea* cf. *johorensis* Foxworthy	1	0.000	-	-	-	+
28	*Shorea* cf. *lamellata* Foxworthy	2	0.006	-	-	-	+
29	*Shorea* cf. *macroptera* Dyer	1	0.001	-	+	-	-
30	*Shorea* cf. *maxwelliana* King	2	0.003	+	-	-	-
31	*Shorea* cf. *obovoidea* van Slooten	8	0.026	+	-	-	-
32	*Shorea* cf. *ovalis* Blume	2	0.004	-	-	-	+
33	*Shorea* cf. *pinanga* Scheff.	2	0.009	+	-	-	-
34	*Shorea fallax* Meijer	10	0.012	-	+	-	-
35	*Shorea hopeifolia* (Heim) Symington	13	0.022	+	+	+	-
36	*Shorea inappendiculata* Burck	7	0.006	-	-	+	-
37	*Shorea johorensis* Foxworthy	36	0.079	+	+	+	+
38	*Shorea leprosula* Miq.	10	0.015	-	+	+	+
39	*Shorea macrocarpa*	2	0.005	+	+	-	-
40	*Shorea macroptera* Dyer	106	0.162	+	+	-	+
41	*Shorea maingayi*	1	0.001	-	+	-	-
42	*Shorea maxwelliana* King	10	0.013	+	-	-	+
43	*Shorea multiflora* (Burck) Symington	21	0.041	+	+	+	-
44	*Shorea ochracea* Symington	2	0.004	-	+	-	-
45	*Shorea ovalis* Blume	15	0.016	+	+	-	+

Table 41. Continued

No	Species	N	BA	PF	LF-5	LF-10	LF30
46	*Shorea parvifolia* Dyer	304	0.525	+	+	+	+
47	*Shorea parvistipulata* Heim	20	0.029	-	-	+	+
48	*Shorea patoiensis* P. S. Ashton	5	0.011	-	-	-	+
49	*Shorea pauciflora* King	45	0.052	+	+	+	+
50	*Shorea peltata* Symington	13	0.035	-	-	-	+
51	*Shorea pinanga* Scheff.	33	0.055	+	-	+	-
52	*Shorea* sp.	74	0.124	+	+	+	+
53	*Shorea* sp. 2	18	0.040	-	+	-	-
54	*Shorea* sp. 1	37	0.045	-	+	+	-
55	*Shorea* sp. 3	24	0.036	-	+	-	-
56	*Shorea venulosa* G. H. S. Wood ex Meijer	1	0.000	-	+	-	-
57	*Shorea xanthophylla* Symington	49	0.094	+	+	-	-
58	*Vatica albiramis* v. Slooten	57	0.080	+	+	-	-
59	*Vatica* cf. *oblongifolia* Hook. f.	1	0.001	-	-	-	+
60	*Vatica granulata* v. Slooten	307	0.476	+	+	-	-
61	*Vatica micrantha* v. Slooten	5	0.010	-	+	-	+
62	*Vatica oblongifolia* Hook.f.	15	0.013	+	+	+	-
63	*Vatica rassak* Blume	4	0.010	-	+	-	-
64	*Vatica* sp.	6	0.009	+	+	-	-
65	*Vatica* sp. 1	1	0.001	-	+	-	-
66	*Vatica umbonata* Burck	40	0.087	+	+	+	+
67	*Vatica vinosa* P.S. Ashton	10	0.014	+	+	-	-
		2092	3.554	38	40	20	28

Table 42. Fifteen leading saplings species based on basal area (BA) in a four 1-ha plots in PF, LF-5, LF-10 and LF-30, in the Bulungan Research Forest, East Kalimantan.

PF		LF-5		LF-10		LF-30	
Species	BA (m^2)	Species	BA (m^2)	Species	BA (m^2)	Species	BA (m^2)
Vatica granulata v. Slooten.	0.27	*Hopea ferruginea* Parijs.	0.24	*Shorea parvifolia* Dyer.	0.29	*Hopea dryobalanoides* Miq.	0.31
Hopea ferruginea Parijs.	0.17	*Vatica granulata* v.Slooten.	0.21	*Macaranga bancana* Muell. Arg.	0.14	*Lophopetalum* sp.	0.16
Mallotus moritzianus Muell. Arg.	0.16	*Syzygium chloranthum* (Duthie) Merrill & Perry.	0.14	*Knema* sp.	0.12	*Koilodepas brevipes* Merr.	0.12
Shorea macroptera Dyer.	0.13	*Shorea parvifolia* Dyer.	0.08	*Aglaia* sp.	0.07	*Knema* sp.	0.11
Shorea parvifolia Dyer.	0.12	*Madhuca magnifica* S. Moore.	0.08	*Macaranga hypoleuca* Muell. Arg.	0.06	*Syzygium* sp.	0.10
Polyalthia cauliflora Hook,f, & Thomson.	0.10	*Syzygium* sp.	0.07	*Elateriospermum tapos* Blume.	0.06	*Diospyros* sp.	0.07
Shorea xanthophylla Symington.	0.09	*Macaranga pruinosa* Muell. Arg.	0.07	*Dryobalanops lanceolata* Burck.	0.05	*Shorea beccarii* Dyer ex Brandis	0.07
Knema cinerea (Poir,) Warb, var *cinerea*	0.09	*Croton argyratus* Blume.	0.07	*Shorea johorensis* Foxworthy	0.04	*Shorea* sp.	0.05
Mallotus eucaustus Airy Shaw.	0.08	*Dacryodes rostrata* (Blume) H, J, Lam forma pubescens	0.06	*Macaranga pearsonii* Merrill	0.04	*Dipterocarpus* sp.	0.04
Diospyros sumatrana Miq.	0.07	*Macaranga gigantea* Muell. Arg.	0.06	*Artocarpus lanceifolius* Roxb.	0.04	*Polyalthia* sp.	0.04
Parashorea malaanonan Merrill	0.06	*Vatica albiramis* v, Slooten	0.05	*Parashorea malaanonan* Merrill	0.04	*Shorea peltata* Symington.	0.03
Dipterocarpus eurynchus Miq.	0.06	*Pternandra rostrata* (Cogn,) M, P, Nayar	0.04	*Syzygium* sp.	0.04	*Madhuca* sp.	0.03
Vatica umbonata Burck.	0.06	*Knema cinerea* (Poir,) Warb, var cinerea	0.04	*Macaranga* sp. 1	0.04	*Mallotus* cf, *griffithianus* (Muell, Arg,) Hook. f.	0.03
Shorea pinanga Scheff.	0.05	*Shorea* sp. 2	0.04	*Macaranga* cf, *depressa* (Muell, Arg,) Muell. Arg.	0.04	*Dialium kunstleri* Prain.	0.03
Koilodepas brevipes Merr.	0.05	*Gluta wallichii* (Hook. f.) Ding Hou	0.04	*Diospyros* sp.	0.04	*Mallotus griffthianus* Hook, f.	0.03

The impact of logging treatment on seedlings and saplings regeneration

Seedlings

LF-30 had the highest number of species of seedlings (265/0.05 ha) and number of individuals (6588/0.05 ha; Table 43), significantly higher number of individuals than LF-10 (2790/0.05 ha).

The differences in mean seedling species numbers among the four logging treatments fell just short of significance at the 95% level (p = 0.07, Table 44), however, pairwise comparisons either by Tukey's family error rate or by Fisher's individual error rate showed significant differences at 95% level between LF-5 and LF-30, with the latter being more species-rich on average. The number of Dipterocarpaceae species was significantly higher in LF-30 (16/0.05 ha) than in any of the other treatments (Table 44); the number of Dipterocarpaceae seedlings was about 10-fold lower in LF-10 (202 vs. a mean range of 2407-2856) than in the other treatments (Table 44). Mean species number (235) and the mean number of individuals (3916) of non-dipterocarps were highest in LF-30. While ANOVA did not give significant differences for the mean number of species of non-Dipterocarpaceae and mean number of seedlings of non-Dipterocarpaceae (Table 45), the number of seedlings in LF-30 appears much higher than in PF.

Table 43. The mean number of species and individuals recorded as seedlings in PF, LF-5, LF-10, and LF-30. Identical letters indicate no statistically significant differences among treatments.

Treatment	N species/0.05 ha	N seedlings/0.05 ha
PF	206a	4854ab
LF-5	170a	5064ab
LF-10	212a	2790b
LF-30	265a	6588a
p -value	0.2053	0.0457

Table 44. The mean number of species seedlings and individuals belonging to the Dipterocarpaceae family recorded in PF, LF-5, LF10, and LF-30. Identical letters indicate no statistically significant differences among treatments.

Treatment	N species/0.05 ha	N seedlings/0.05 ha
PF	2b	2856a
LF-5	1b	2407ab
LF-10	3b	202b

LF-30	16a	2672ab
p -value	<0.0001	0.0132

Table 45. The number of species seedlings and individuals belonging to the non-Dipterocarpaceae family recorded in PF, LF-5, LF10, and LF-30. Identical letters indicate no statistically significant differences among treatments.

Treatment		
	N species/0.05 ha	N seedlings/0.05 ha
PF	204a	1998a
LF-5	170a	2657a
LF-10	207a	2587a
LF-30	235.25	3916a
p -value	0.3518	0.0863

Saplings

PF had the highest total number of saplings (641/0.2 ha; Table 46) and number of Dipterocarpaceae saplings (197/0.2 ha; Table 47). LF-5 had significantly higher number of sapling species (191) than either PF (147), LF-10 (122) or LF-30 (89) (Table 46). A similar trend is evident for the number of sapling individuals, however, a large plot to plot variation caused the result to fall short of significance (Table 46). The lowest number of species of Dipterocarpaceae was recorded from LF-10 (10), significantly lower than in any other treatments (Table 47). The number of dipterocarp saplings was not different statistically because of high plot to plot variation, however, there is an indication (in the absence of a larger sample size) that LF-30 (79) might have significantly less saplings than PF (197) or LF-5 (154). The results for the number of non-Dipterocarpaceae species and their individuals are similar to the results obtained for dipterocarps (Table 48).

Table 46. The number of species of saplings and individuals in PF, LF-5, LF-10 and LF-30. Identical letters indicate no statistically significant differences among treatments.

Treatment		
	N species/0.05 ha	N saplings/0.05 ha
PF	147ab	641a
LF-5	191a	638a
LF-10	122bc	402a
LF-30	89c	288a
p -value	0.0013	0.1731

Table 47. The number of species of saplings and individuals of the Dipterocarpaceae family in PF, LF-5, LF-10 and LF-30. Identical letters indicate no statistically significant differences among treatments

Treatment	N species/0.05 ha	N saplings/0.05 ha
PF	19a	197a
LF-5	21a	154a
LF-10	10b	93a
LF-30	13ab	79a
p -value	0.0089	0.1731

Table 48. The number of species of saplings and individuals of non-Dipterocarpaceae family in PF, LF-5, LF-10 and LF-30. Identical letters indicate no statistically significant differences among treatments

Treatment	N species/0.05 ha	N saplings/0.05 ha
PF	126ab	444a
LF-5	173a	485a
LF-10	110bc	309ab
LF-30	76c	209b
p -value	0.0015	0.0033

DISCUSSION

As Whitmore (1982) has pointed out, regeneration processes are similar in essentials in tropical and temperate forests, but in the former they are more complex and the patterns of phases more diverse because of their much greater richness in tree species. Natural regeneration dynamics of dipterocarp forest are connected to the formation of gaps occurring after sporadic treefalls or other relatively small disturbances. Seedlings and saplings formerly suppressed by a closed canopy commence their growth after a gap is opened up. The existing seedling stock (of which some species are ephemeral, whilst others can persist in deep shade for many years) and the new recruits from germinating seeds (of light demanding species) dispersed into the gap determine species composition and heterogeneity of the forest patch after disturbance (Whitmore 1978, Brokaw 1985, Denslow 1987).

Regeneration is part of forest ecosystem dynamics which is influenced by environmental perturbations, such as logging. Seedlings and saplings are very responsive to changes in light intensity; many species respond to increased light availability by increased growth (e.g. Lamprecht 1989), whilst some lower canopy species may be unfavourably affected by excess light. Changing canopy density by opening up the forest can dramatically affect the intensity of light received by the forest floor. In general, after logging, such as in LF-5 and LF-10 in this study, the canopy opening is very high. Later, such as in our LF-30, the canopy closure of the stand can be high, but in patches, it may remain low. The impact of logging on saplings resulted in lower densities in logged forest than in primary forest (Table 46). This may have been caused simply by logging damage. The felling of large trees damages or kills many smaller trees, thereby the number of saplings can decrease after logging, such as it has been reported from Bukit Soeharto by Okimori (1991) and from PT. Gani Mulia Abadi by Matius (1991) and from PT. ITCI by Soedirman (1993; see also Table 49). This is in accordance with Adjers *et al.* (1995), who also reported that the number of saplings and seedlings of commercial dipterocarp species in logged forest was low, especially if the forest has been heavily logged or burnt. Another possible cause of a reduction in sapling numbers, alone or in combination with felling damage, is the temporal dynamics of pioneer species which invaded large felling gaps immediately after logging. The ranking of the Euphorbiaceae family second after the Dipterocarpaceae in this study and the occurrence of

Macaranga species among the top 15 dominant species is an indication of that (note that the Euphorbiaceae also has many shade bearing species in primary forest).

In primary forest and old logged forest, recruitment rate matches mortality (Swaine *et al.* 1987). Studies on mortality and recruitment in logged forest have indicated higher mortality than recruitment and this is in accordance with Manokaran & Kochummen (1987) and Lang & Knight (1983) who found that in certain periods of succession mortality exceeds recruitment. High mortality in newly logged forest such as in LF-10 reflects the medium-term effects of logging damage. LF-10 had 10-fold lower number of dipterocaps seedling and lower numbers of dipterocarp saplings even compared to LF-5. The answer to this phenomenon is simply due to the open area in LF-5 which had a large number of seedlings of light demanding pioneers species, such as *Macaranga* spp. and *Anthocephallus* spp. rather than shade tolerant species in the large gaps. Although Dawkins (1958) stated that there is no increment of sapling growth after logging but in term of basal area, all forest types were dominated by Dipterocarpaceae family (Table 40). In this study, we found that LF-30 had a good quality of forest in terms of floristic composition and stand structure, similarly to that reported by Soedirman (1993) who found that the number of trees in older logged forest was greater than in the newly logged forest. In addition, Soedirman's study showed that the older logged forests were dominated by young trees up to 75%, the similar case to that also found in this study, where the regeneration of seedling species as well as the number of individuals in LF-30 was better than LF-5 and LF-10.

Table 49. Number of seedlings (< 2 cm dbh) and number of saplings (2 – 9.9 cm dbh) in primary lowland dipterocarp forest and logged forest in Kalimantan.

Location	alt	Plot size	No. of seedlings	Plot size	No. of saplings	References
East Kalimantan						
BRF-CIFOR						
PF	100	Mean of four 1-ha	4,854	Mean of four 1-ha	641	this study
LF-5	100	Mean of four 1-ha	5,064	Mean of four 1-ha	638	
LF-10	100	Mean of four 1-ha	2,790	Mean of four 1-ha	402	
LF-30	100	Mean of four 1-ha	6,588	Mean of four 1-ha	288	
RIL-CIFOR	100	-	-	Means 1-ha	4,600	Priyadi *et al.* (2005)
Bukit Suharto Forest						Okimori (1991)
Light logging	60-100	1-ha	51,600	1-ha	4,150	
Medium logging	60-100	1-ha	20,833	1-ha	3,681	
Heavy logging	60-100	1-ha	3,889	1-ha	3,472	
PT. Gani Mulia Abadi						
Light logging	400	1-ha	17,475	1-ha	1,224	Matius (1991)
Heavy logging	400	1-ha	25,459	1-ha	1,352	
P.T. ITCI						Soedirman (1993)
LF-3	100	4 m^2	27	25 m^2	40	
LF-6	100	4 m^2	53	25 m^2	66	
LF-10	100	4 m^2	77	25 m^2	25	
LF-15	100	4 m^2	107	25 m^2	38	
South Kalimantan						Jafarsidik 1998
Kintap Forest	100	Means 1-ha	73,920	Means 1-ha	5,163	
Kintap Forest						Kuusipalo *et al*. 1996
PF	100	100 m^2	325	-	-	
LF-12	100	100 m^2	530	-	-	
Kintap Gap forest	100	845 m^2	599	-	-	Tuomela *et al*. (1994)

Canopy opening in LF in contrast to PF stimulated the growth of seedlings (compare Table 43 and 46). A study by Seng *et al* (2004) in Peninsular, Malaysia showed that the mean basal area and the density of tree seedling and saplings with dbh < 5 cm was reduced by 150% of the original stand after logging in one compartment but also found an increment of up to 24.3% in another compartment. They also found that there were no changes in species composition before and after logging. Similar results were found by Chapman & Chapman (1997) in Kibale National Park in Uganda where there were no differences in the density and species richness of seedlings in the logged and unlogged forests. Similarly, our study showed little difference between PF and LF: the number of seedlings was reduced in LF-10 compared to PF but more seedlings were found in LF-5 and LF-30 than in PF. Seedlings of *Hopea dryobalanoides* were dominant in PF, LF-5 and LF-30 in this study. This fact indicated that the future harvesting is dominated by timber from the family Dipterocarpaceae especially *Hopea dryobalanoides*.

LF-5 had a vigorous regeneration in this study: the highest number of species and stems of saplings (both Dipterocarpaceae and non-Dipterocarpaceae). This phenomenon may due to the greater light intensity in LF-5 compared to the other plots.

All dipterocarps have seeds that can germinate and establish as seedlings beneath the shade of a closed canopy (Newman *et. al.*, 1996; Whitmore, 1996). The seedlings of a number of species can persevere for many years, but some (e.g. *Cotylelobium melanoxylon*) will die within a year or so (L. Nagy pers. comm.). Kuusipalo *et al.* (1996) reported a similar result: seedling density tends to be higher in a logged forest than in unlogged forest, due to the higher light intensity. The numbers of Euphorbiaceae was higher in LF-10 than in other plots, while Dipterocarpaceae had the highest basal area in PF, LF-5 and LF-30 (Table 40). This fact shows that Dipterocarpaceae regeneration is still greater than that of other families. This was because the basal area of Dipterocarpaceae is relatively higher than other families and canopy conditions promote the early growth of seedlings of Dipterocarpaceae. They then more or less cease growing in height until 'released' when the canopy above them is opened. The regeneration (seedlings and saplings) recorded in all treatments is encouraging with regard to producing future harvestable timber.

An example of tagged saplings and a natural gap in PF can be seen in Figure 30.

Figure 30. Saplings with aluminium tags and signed of Block (above) and natural gap of about 800 m^2 with *Shorea parvifolia* saplings in PF.

CHAPTER 5. SOILS

INTRODUCTION

Forests produce greater soil stability than any other vegetation type because of their high infiltration rates, protective ground cover, high consumption of soil water and high tensile strength of roots (FAO 2003). These attributes are particularly beneficial in a region with a high rainfall like the Bulungan Research Forest in East Kalimantan. Many remaining parts of tropical forest in Indonesia lie upon hilly and mountainous regions. Logging activities in such areas have a large potential to cause erosion and landslides (Sidle 2000 *in* FAO 2003). This is because logging interferes with the soil and its hydrological properties directly through churning and compaction. There are also indirect logging associated impacts on soil and soil processes by changing surface temperature. Current logging practices largely ignore collateral damage caused to soil, (also to remaining forest stock and hydrology).

The microclimatic changes due to forest clearing from dark, moist, cool and wind free to dry, hot and exposed to air movement directly affect the vegetation, such as residual trees and saplings and seedlings (Ewel & Conde 1980). Due to the nature of its implementation, logging causes compaction in the soil profile. Further more, the degree of soil compaction affects soil bulk density and organic matter distribution (Siregar 2004).

For example, Putz (1994) attributed logging damage that results in the destruction of natural regeneration and increased susceptibility to soil loss, wildfires, and weed infestations to lack of adequate management plans. Good and reliable information on logging impacts for management planning is a must for sustaining the forest resource. Forest conservation has to focus not only on primary (unlogged) forest but also on logged forest (Meijaard *et al.* 2005).

This chapter investigates changes to soil properties after logging. In particular, the distribution of soil bulk density and evaluation of soil organic matter as affected by logging activities in different age of logged forest. Forest land fertility and its potential suitability for crops were also evaluated. This study is designed to clarify the ecological effect caused by timber harvesting and to find out the answer whether the forest surrounding the study area is feasible to be converted into other potential conversion.

METHODS

Soil survey

This soil survey was carried out in cooperation with Mr. Imam Basuki, a soil scientist at CIFOR, Bogor, Indonesia.

Soil profile description

Two soil profiles were described from 1 m deep soil pits for each of the 16 1-ha permanent plots used for tree recording and described in Chapters 2 and 3 , one about 5 m uphill and the other 5 m downhill from the plot edge. If stones prevented digging to 1 m depth, digging was stopped and the depth reached was recorded.

Profiles were described using procedures outlined by Suwardi & Wiranegara (1998). Physical characteristics noted included depth, moisture regime, colour, texture, structure, consistency, and pore distribution.

Soil sampling

Two types of soil samples were collected: (1) surface samples from intact forest floor not affected by skidding; and (2) surface samples from skid trails. Five sample points were randomly chosen from each 1-ha plot to represent areas without skid trails and another five from skid trails based on the length and form of the trails (Figure 31 and Appendix 8). Five samples were taken from the soil surface of each plot using a 5 cm diameter stainless steel ring with a volume of 167.48 cm^3. Before extracting the core, the vegetation was cleared. All samples were taken in duplicate; the physical and chemical properties determined were identical to those for the profile samples.

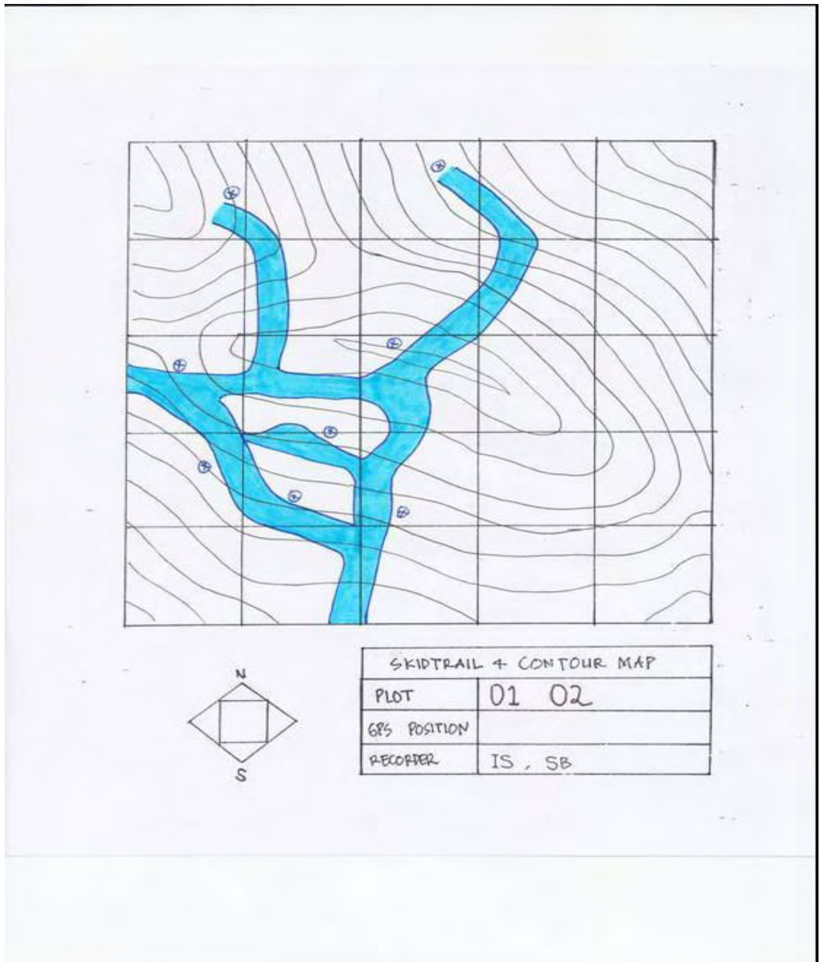

Figure 31. An example of sampling near a skid trail from Plot 2 of LF-30

Soil analysis

All measurements made in the laboratory are detailed in the Soil Division [Jurusan Tanah] (1992) for physical and in the Indonesian Soil Research Center [Puslittanak] (1998) for chemical characteristics.

Physical measurements

Texture (pipette procedure)

Organic material was oxidised by H_2O_2 and soluble salts removed from the soil by HCl and heating. The remaining particles were minerals in the form of sand, silt and clay. Wet sieving separated the sand, in the first place, and sedimentation separated the silt from the clay.

Bulk density (gravimeter procedure)

Samples were dried in an electric oven at 105^o C to achieve constant weight (24 hours). Dry density (D_d) was calculated as (mass after drying) / ring volume (167.48 cm^3).

Chemical measurements (Puslittanak 1998)

pH value (KCl and H_2O procedures)

1. Organic Carbon (Kurmis procedure)
2. Total Nitrogen (Kjeldahl procedure)
3. Available Phosphorus (= P_2O_5, by Bray I procedure)
4. Exchangeable bases, base saturation (BS), cation exchange capacity (CEC), acidity, aluminum, and iron concentration (this series of evaluations follows the sequential steps of "NH_4OAc/ 23rd procedure", of Puslittanak 1998). The soils were analysed by the Indonesian Soil Research Center (Puslittanak), Bogor.

Fertility evaluation

Soil fertility was assessed using CEC (me/100g), base saturation (%), P_2O_5 (ppm), K^+ (me/100g) and C-org (%) (Staf Peneliti 1983). The value of each indicator was then translated to scale of 1 to 5 and used to classify fertility. Exchangeable rather than available K^+ and available rather than total phosphorus were used in this evaluation, as this is more relevant to actual fertility.

Statistical analyses

The statistical significance of differences among treatments means was assessed using one-way analyses of variance (ANOVA). Where results indicated significant ($p<0.05$) treatment effects, Tukey's HSD test was used to determine the levels of significance among the treatment means. The data were analysed using Microsoft Excel 2003 and JMP 5.1 statistical programme published by SAS Institute in United States.

Land evaluation

As described in Basuki & Sheil (2005) 'land evaluation' means an area's potential for specific land-uses. Land and soil qualities, such as drainage and nutrient content, can play a significant role in determining the appropriateness/suitability for a chosen activity. Each sample plot was evaluated for its potential for sustained production under seven crops: upland-rice (*Oryza sativa*), oil palm (*Elaeis guineensis*), black pepper (*Piper nigrum*), coffee (*Coffea arabica*), cocoa (*Theobroma cacao*), candlenut (*Aleurites moluccana*) and rubber (*Hevea brasiliensis*) using the Standard Indonesian Department of Agriculture classification procedures (Biro Perencanaan 1997). For each plot the primary limiting factor was used to determine the plot's suitability. That is the factor or measure that is most unsuited to the crop in question.

Each plot was then rated highly suitable (S1), moderately suitable (S2), marginally suitable (S3), or permanently not suitable (N). S2 land has 'light limiting factors and only requires minimum input in order to support a sustainable yield of a selected crop'. S3 land (marginally suitable) has 'considerable limiting factors and requires sizeable inputs in order to support a sustainable yield of a determined crop'. Land is considered 'permanently unsuitable' when it is 'neither economically nor biologically sustainable for a selected crop' (Biro Perencanaan 1997).

The evaluation/matching process between plot site characteristics and crop requirements was carried out using a Boolean logic formula in Microsoft Excel. This process is outlined below.

Formula-1. Example of the Boolean logic (using MS-excel logic) to construct a formula for the land suitability class values of cationic exchange capacity (CEC)

```
= IF (CEC = "","", IF (CEC >16, S1, IF (CEC <= 16, S2,0)))
```

This means that if CEC is >16, the maximum possible land suitability class for pepper will be S1 or "very suitable". Such criteria are applied until all characteristics have been evaluated. Then suitability is determined using the lowest rated characteristic.

RESULTS

Soil survey

Soil under lowland dipterocarp forests in the study area is oxisols (Basuki & Sheil, 2005). Full soil profile (Figure 32) descriptions from 32 pits are presented in Appendix (10).

The impacts of logging on intact soil and on skid trail

Soil physical and chemical characteristics

Altogether, there were 140 surface samples: 60 skid trail samples (no skid trails in primary forest) and 80 surface samples from the intact forest floor not affected by skidding.

Results obtained from this study shows that soil bulk density, pH (KCl) and C are significantly different from one site to another (LF-5, LF-10, LF-30, and PF, Table 50 and 51). This information is further indicates that the characteristics of soil in the study sites are naturally different.

To see the different of skid trail and intact soil on different logging ages, the data were analyzed using completely randomized design using 4 replications in each forest type. The treatment that were tested are: PF (only intact soil), LF-5 + intact soil, LF-10 + intact soil, LF-30 + intact soil, LF-5 + skid trail, LF-10 + skid trail and LF-30 + skid trail. The effect of skid trail and intact soil across all logging ages is significant on the soil physical properties. While the effect of skid trail and intact soil has no significant impact on the soil physical properties at the same levels of logging ages. This indicated that skid trail activities did not damage the soil physical properties severely as compared to the intact soil plots and this trend was observed at all logging ages. The analysis result of physical soil properties of skid trails and intact soil comparison at different levels of logging can be seen in Table 52. The result of soil chemical properties analysis is similar with soil physical properties analysis, except on C, N, C/N and Fe. On LF-10, the effect of skid trail and intact soil has significant results on C, N and Fe. While on LF-5 it has significant results on C/N. This indicated that skid trail activity on LF-10 reduced C, N and Fe significantly, while on LF-5 it reduced C/N significantly. The analysis comparison of chemical soil properties of skid trails and intact soil at different levels of logging can be seen in Table 53. The improvement of the soil chemical properties may occurred due to the increase in gap opening inducing the rate of decomposition of debris in forest surface.

Across intact soils and skid trail soils, soil bulk density and pH (KCl) bearing lower values in more recently logged plots (Table 54). In contrast, C content fluctuated: it is higher in LF-5 and LF-10 but lower in LF-30. Bulk density is significantly different between PF and LF-30 but not significantly different from LF-5 and LF-10. The pH (KCl) in PF is significantly different from LF-10 but not from LF-5 and LF-30. C in PF is not significantly different from logged forest plots.

No significant difference was found on non-skid trail at different soil depths from 0-10 cm of LF-5, LF-10 and LF-30 on soil physical and chemical characteristic such as sand, silt, clay-course, clay-fine, pH (H_2O), N, C/N, P_2O_5, Ca, Mg, K, Na, Bases, CEC, BS, Al, H and Fe (Table 54).

Nitrogen tended to increase with increasing logging age (LF-5 and LF-10), but decrease in LF-30 (Table 54). Phosphorus was relatively fluctuating with increasing logging age (Table 54). Potassium, sodium, magnesium and hydrogen in PF was higher than potassium, sodium, magnesium and hydrogen in LF-5, LF-10 and LF-30 (Table 54). LF-5 reached the highest aluminum and CEC concentrations, while calcium concentration tended to increase with increasing logging age (Table 54). Base saturation tended to increase with increasing logging age (Table 54).

Figure 32. Soil profile in LF-30 (above) and new logging road along primary forest in the Bulungan Research Forest, East Kalimantan.

Table 50. Summary of significance tests after one-way analyses of ANOVA carried out separately for intact surface soil and skid trails on each soil physical property from PF, LF-5, LF-10 and LF-30, in the Bulungan Research Forest, East Kalimantan

Soil physical characteristic	**Logging treatment effect**	
	p-value intact soil	**p-value skid trail**
Bulk density (gr/cm^3)	0.0044**	0.0693ns
Sand (%)	0.0996ns	0.0252*
Silt (%)	0.1048ns	0.0136*
Clay-coarse (%)	0.2025ns	0.1000ns
Clay-fine (%)	0.1375ns	0.0723ns

*, significant at 95% level; **, significant at 99% level; ns, not significant

Table 51. Summary of significance tests after one-way analyses of ANOVA carried out separately for intact surface soil and skid trails on each soil chemical property from PF, LF-5, LF-10 and LF-30, in the Bulungan Research Forest, East Kalimantan

Soil chemical characteristic	Logging treatment effect	
	p-value Intact soil	p-value Skid trail
pH H_2O	0.8090ns	0.0594ns
pH KCl	0.0041**	0.0231*
C (%)	0.0247*	0.1189ns
N (%)	0.1156ns	0.0829ns
C/N	0.3882ns	0.0114*
P_2O_5 (ppm)	0.2264ns	0.4081ns
Ca^{2+} (me/100g)	0.4707ns	0.7081ns
Mg^{2+} (me/100g)	0.9278ns	0.8898ns
K^+ (me/100g)	0.2612ns	0.2015ns
Na^+ (me/100g)	0.1724ns	0.4633ns
Bases (me/100g)	0.8543ns	0.7861ns
CEC (me/100g)	0.1738ns	0.0696ns
Base Saturation	0.6102ns	0.6092ns
Al^{3+} (me/100g)	0.1399ns	0.0658ns
H^+ (me/100g)	0.0595ns	0.0303*
Fe^{3+} (ppm)	0.1688ns	0.1147ns

*, significant at 95% level; **, significant at 99% level; ns, not significant

Table 52. Physical soil properties of skid trails and intact soil at different levels of logging

Forest type	Logging treatment effect	Soil physical properties				
		Bulk density (gr/cm^3)	Sand (%)	Silt (%)	Clay-coarse (%)	Clay-fine (%)
PF	Intact soil	1.04b	33.38bc	37.01ab	18.87abc	10.75cd
LF-5	Intact soil	1.09b	41.18ab	23.82c	14.88bcd	20.13ab
LF-10	Intact soil	0.98b	19.91cd	45.52a	19.71ab	14.86bc
LF-30	Intact soil	1.39a	54.44a	26.53c	12.01d	7.03d
LF-5	Skid trail	1.11b	36.11b	22.30c	17.42bcd	24.19a
LF-10	Skid trail	1.10b	16.02d	44.83a	24.11a	15.04bc

LF-30	Skid trail	1.43a	48.11ab	30.49bc	12.51cd	8.89cd
p-value		< 0.0001**	< 0.0001**	< 0.0001**	< 0.0001**	< 0.0001**

Note: Numbers followed by same letter indicates not significant at 95% level; ** , significant at 99% level

Table 53. Chemical soil properties of skid trails and intact soil at different levels of logging

Forest type	Logging treatment effect	Soil chemical properties			
		pH H_2O	pH KCl	C (%)	N (%)
PF	Intact soil	4.09b	3.70c	1.82ab	0.16ab
LF-5	Intact soil	4.11b	3.73c	2.07ab	0.18a
LF-10	Intact soil	4.25ab	3.95ab	2.36a	0.17a
LF-30	Intact soil	4.10b	3.83bc	1.10c	0.10c
LF-5	Skid trail	4.31ab	3.79bc	1.44bc	0.14abc
LF-10	Skid trail	4.48a	4.01a	1.60bc	0.12bc
LF-30	Skid trail	4.01b	3.74c	1.08c	0.09c
p-value		0.0013**	< 0.0001**	< 0.0001**	< 0.0001**
		C/N	P_2O_5 (ppm)	Ca^{2+} (me/100g)	Mg^{2+} (me/100g)
PF	Intact soil	11.65bc	11.83a	0.28a	0.57a
LF-5	Intact soil	12.70ab	7.29ab	0.83a	0.50a
LF-10	Intact soil	13.40ab	9.71ab	1.28a	0.45a
LF-30	Intact soil	11.45bc	6.43b	1.38a	0.33a
LF-5	Skid trail	9.90c	5.44b	0.71a	0.35a
LF-10	Skid trail	14.05a	7.49ab	0.98a	0.28a
LF-30	Skid trail	12.11ab	6.66ab	0.56a	0.28a
p-value		< 0.0001**	0.0077**	0.2026ns	0.4485ns
		K^+ (me/100g)	Na^+ (me/100g)	Bases (me/100g)	CEC (me/100g)
PF	Intact soil	0.23a	0.07ab	1.15a	10.07b
LF-5	Intact soil	0.17ab	0.10a	1.59a	15.72a
LF-10	Intact soil	0.17ab	0.08ab	1.98a	9.33b
LF-30	Intact soil	0.13b	0.04b	1.87a	6.08b
LF-5	Skid trail	0.14b	0.06ab	1.26a	18.16a
LF-10	Skid trail	0.13b	0.07ab	1.46a	9.72b
LF-30	Skid trail	0.11b	0.06ab	1.01a	6.95b
p-value		0.0001**	0.0117*	0.6095ns	< 0.0001**
		Base Saturation	Al^{3+} (me/100g)	H^+ (me/100g)	Fe^{3+} (ppm)
PF	Intact soil	11.15ab	6.81bc	0.68ab	44.13a
LF-5	Intact soil	14.05ab	9.90ab	0.86a	38.76ab
LF-10	Intact soil	21.95ab	3.61c	0.31c	42.38a
LF-30	Intact soil	28.45a	4.71c	0.36bc	34.34b
LF-5	Skid trail	9.65b	12.52a	0.94a	43.70a
LF-10	Skid trail	16.15ab	4.86c	0.36bc	35.47b
LF-30	Skid trail	14.42ab	6.26bc	0.48bc	33.64b
p-value		0.0428*	< 0.0001**	< 0.0001**	0.0390*

Note: Numbers followed by same letter indicates not significant at 95% level; * , significant at 95% level; ** , significant at 99% level; ns , not significant

Table 54. Summary statistics carried out separately for intact surface soil and skid trails on each soil physical and chemical property from PF, LF-5, LF-10 and LF-30, in the Bulungan Research Forest, East Kalimantan.

Characteristics	Logging treatment	Intact			Skid trail		
		mean	s.d.	n	mean	s.d.	n
Bulk density (g/cm^3)	PF	1.04	0.15	20	-	-	-
	LF-5	1.09	0.23	20	1.11	0.32	20
	LF-10	0.98	0.17	20	1.10	0.15	20
	LF-30	1.39	0.15	20	1.43	0.17	20
Sand (%)	PF	33.38	13.07	20	-	-	-
	LF-5	41.18	27.51	20	36.11	18.84	20
	LF-10	19.91	11.19	20	16.02	4.44	20
	LF-30	54.44	12.28	20	47.62	14.11	20
Silt (%)	PF	37.01	8.9	20	-	-	-
	LF-5	23.82	16.46	20	22.3	11.65	20
	LF-10	45.52	8.23	20	44.83	3.58	20
	LF-30	26.53	10.2	20	30.62	9.56	20
Clay-coarse (%)	PF	18.87	4.31	20	-	-	-
	LF-5	14.88	7.89	20	17.42	7.79	20
	LF-10	19.71	6	20	24.11	7.39	20
	LF-30	12.01	7.78	20	12.54	5.56	20
Clay-fine (%)	PF	10.75	3.36	20	-	-	-
	LF-5	20.13	14.4	20	24.19	11.65	20
	LF-10	14.86	4.7	20	15.04	4.87	20
	LF-30	7.03	3.23	20	9.22	2.90	20
pH H_2O	PF	4.07	0.37	20	-	-	-
	LF-5	4.09	0.37	20	4.31	0.32	20
	LF-10	4.25	0.32	20	4.47	0.37	20
	LF-30	4.09	0.41	20	4.02	0.40	20
pH KCl	PF	3.69	0.13	20	-	-	-
	LF-5	3.71	0.18	20	3.77	0.12	20
	LF-10	3.95	0.17	20	4.01	0.17	20
	LF-30	3.83	0.3	20	3.73	0.11	20
C (%)	PF	1.82	0.5	20	-	-	-
	LF-5	2.07	0.97	20	1.44	0.97	20
	LF-10	2.36	0.94	20	1.6	0.84	20
	LF-30	1.10	0.25	20	1.08	0.35	20
N (%)	PF	0.16	0.04	20	-	-	-
	LF-5	0.18	0.09	20	0.14	0.08	20
	LF-10	0.17	0.05	20	0.12	0.06	20
	LF-30	0.10	0.02	20	0.09	0.03	20
C/N	PF	11.64	1.76	20	-	-	-

Table 54. Continued

Characteristics	Logging treatment	Intact			Skid trail		
	LF-5	12.76	2.78	20	9.93	2.05	20
	LF-10	13.39	2.25	20	14.04	2.03	20

Characteristics	Logging treatment	Intact			Skid trail		
	LF-30	11.54	2.05	20	11.99	1.45	20
P_2O_5 (ppm)	PF	11.83	7.69	20	-	-	-
	LF-5	7.29	6.71	20	5.44	5.02	20
	LF-10	9.71	5.94	20	7.49	5.99	20
	LF-30	6.43	3.42	20	6.59	2.59	20
Ca^{2+} (me/100g)	PF	0.28	0.38	20	-	-	-
	LF-5	0.83	1.86	20	0.71	0.67	20
	LF-10	1.28	1.87	20	0.98	1.21	20
	LF-30	1.38	2.17	20	0.59	0.91	20
Mg^{2+} (me/100g)	PF	0.57	0.65	20	-	-	-
	LF-5	0.50	0.87	20	0.35	0.29	20
	LF-10	0.45	0.38	20	0.28	0.17	20
	LF-30	0.33	0.41	20	0.28	0.40	20
K^{+} (me/100g)	PF	0.23	0.12	20	-	-	-
	LF-5	0.17	0.09	20	0.14	0.05	20
	LF-10	0.17	0.12	20	0.13	0.04	20
	LF-30	0.13	0.05	20	0.11	0.06	20
Na^{+} (me/100g)	PF	0.07	0.06	20	-	-	-
	LF-5	0.10	0.05	20	0.06	0.04	20
	LF-10	0.08	0.06	20	0.07	0.06	20
	LF-30	0.04	0.02	20	0.06	0.04	20
Bases (me/100g)	PF	1.15	1.03	20	-	-	-
	LF-5	1.59	2.75	20	1.26	0.95	20
	LF-10	1.98	2.25	20	1.46	1.35	20
	LF-30	1.87	2.51	20	1.04	1.19	20
CEC (me/100g)	PF	10.07	1.81	20	-	-	-
(me/100g)	LF-5	15.72	10.29	20	18.16	10.08	20
	LF-10	9.33	2.24	20	9.72	2.91	20
	LF-30	6.08	1.31	20	7.04	1.46	20
Base Saturation	PF	11.16	9.58	20	-	-	-
	LF-5	14.04	21.41	20	9.6	8.44	20
	LF-10	22.00	21.93	20	16.16	17.37	20
	LF-30	28.41	31.96	20	14.65	15.44	20
Al^{3+} (me/100g)	PF	6.81	1.92	20	-	-	-
	LF-5	9.90	7.14	20	12.51	7.52	20
	LF-10	3.61	1.34	20	4.86	2.66	20
	LF-30	4.71	2.5	20	6.12	1.59	20

Table 54. Continued

Characteristics	Logging treatment	Intact			Skid trail		
H^{+} (me/100g)	PF	0.68	0.26	20	-	-	-
	LF-5	0.86	0.62	20	0.94	0.53	20

Characteristics	Logging treatment	Intact			Skid trail		
	LF-10	0.31	0.12	20	0.36	0.24	20
	LF-30	0.36	0.19	20	0.48	0.18	20
Fe^{3+} (ppm)	PF	44.13	12.04	20	-	-	-
	LF-5	38.76	13.04	20	43.7	14.21	20
	LF-10	42.38	12.75	20	35.47	12.71	20
	LF-30	34.34	15.71	20	33.64	11.76	20

Soil fertility and the evaluation land suitability for crop production

Fertility at all plots was low to very low for crop production (Table 55). Sites with the least fertile soil were found in LF-5 and LF-30 both on skid trail and non-skid trail, where phosphorus and potassium availability were reduced. Most of crops evaluated show S3 (marginal) or N (not suitable) class of suitability, while candlenut show N class for all sites (Table 56). It is only for coconut, peanut and rice that this area shows S2 (moderate) class of suitability. The results confirm that the production forest area would only support forestry activities.

Table 55. Soil Fertility Class by logging treatment (PF, LF-5, LF-10, LF-30), sample (intact vs. skid trail) for each plot using Criteria from Indonesian Soil Research Center (LPT 1983), n=140

Treatment	Surface type	Plot	C	P_2O_5	K_2O	CEC	B%	Fertility
PF	**Intact**	1	1.86	10.15	0.22	9.42	5.98	Low
		2	2.01	14.28	0.37	11.60	22.10	Low
		3	1.49	7.99	0.15	9.35	5.99	Low
		4	1.92	14.91	0.19	9.93	10.56	Low
LF-5	**intact**	1	2.55	3.41	0.18	28.94	3.48	Low

Treatment	Surface type	Plot	C	P_2O_5	K_2O	CEC	B%	Fertility
		2	0.93	10.65	0.12	4.10	18.54	Low - Very low
		3	2.55	11.63	0.12	14.00	4.63	Low - Very low
		4	2.23	3.47	0.25	15.83	29.51	Low
	Skid trail	1	1.73	4.95	0.14	27.97	3.32	Low
		2	1.05	8.34	0.12	5.46	17.91	Low - Very low
		3	2.12	6.23	0.10	19.26	2.96	Low
		4	0.85	2.26	0.20	19.98	14.21	Low
LF-10	**Intact**	1	2.32	14.10	0.24	7.85	33.58	Low
		2	2.17	7.53	0.12	10.29	8.90	Low
		3	3.02	10.23	0.18	10.56	8.75	Low
		4	1.92	6.96	0.15	8.61	36.76	Low
	Skid trail	1	1.66	10.24	0.09	7.92	27.97	Low
		2	1.90	10.62	0.13	9.78	10.32	Low
		3	1.63	5.13	0.15	8.17	12.24	Low
		4	1.19	3.98	0.16	12.99	14.11	Low
LF-30	**Intact**	1	1.02	5.78	0.13	4.87	18.22	Low - Very low
		2	1.07	6.06	0.17	6.13	58.76	Low - Very low
		3	1.24	5.85	0.08	6.67	27.04	Low
		4	1.09	8.04	0.14	6.66	9.62	Low
	Skid trail	1	1.28	6.48	0.08	6.76	6.20	Low
		2	1.11	6.29	0.10	6.96	29.67	Low
		3	1.22	8.04	0.10	7.10	8.65	Low
		4	0.72	5.55	0.15	7.35	14.07	Low to Very low

Table 56. Suitability Class for each plot in PF, LF-5, LF-10, and LF-30 using Criteria from Indonesian Department of Agriculture (Biro Perencanaan 1997), n=140

Logging treatment	Plot	Cocoa	Candlenut	Rubber	Coffee	Rice	Pepper	Peanut	Coconut	Oil-palm
PF	1	S3	N	S3-N	S3-N	S3	S3	N	S2-S3	S3
	2	S3-N	N	S3-N	S3-N	S3-N	S3-N	N	S2-N	S3-N
	3	S3	N	N	N	S3	S3	N	S3	S3
	4	S3	N	S3-N	S3-N	S3	S3	N	S2-S3	S3
LF-5	1	S3-N	N	S3-N	S3-N	S3	S3-N	N	S2-S3	S3-N
	2	S3-N	N	S3-N	S3-N	S3-N	S3-N	N	S2-S3-N	S3-N
	3	S3-N	N	S3-N	S3-N	S3-N	S3-N	N	S2-S3-N	S3-N
	4	S3	N	S3	S3	S2-S3	S3	N	S2	S3
LF-10	1	S3-N	N	S3-N	S3-N	S3	S3	N	S2-S3	S3

Logging treatment	Plot	Cocoa	Candlenut	Rubber	Coffee	Rice	Pepper	Peanut	Coconut	Oil-palm
	2	S3	N	S3	S3	S3	S3	N	S2	S3
	3	S3	N	S3	S3	S3	S3	N	S2	S3
	4	S3	N	S3	S3	S3	S3	N	S2-S3	S3
LF-30	1	S3-N	N	S3-N	S3-N	S3	S3-N	N	S2-S3	S3-N
	2	N	N	N	N	S3-N	N	N	S3-N	S3-N
	3	S3-N	N	S3-N	S3-N	S3-N	S3-N	N	S2-S3-N	S3-N
	4	N	N	N	S3-N	S3-N	N	S3-N	S3-N	S3-N

DISCUSSION

The summary statistics suggest that the laboratory analyses in this study were largely consistent with the results obtained by Basuki & Sheil (2005) for the area. All soils are acidic (pH (H2O) 4.1-4.4) and are low carbon, phosphorus, potassium, base saturation and CEC.

The main soil types of Kalimantan (MacKinnon *et al.* 1996) range from histosols (bearing peat swamp forest) to heavily weathered spodosols (under heath forest) and oxisols (under tall lowland evergreen rainforest), such as at BRF. According to Basuki & Sheil (2005), soil types in the study area are oxisols. However, Siregar *et al.* (2005), reported that soils under lowland forest in his study area, which was in relatively close proximity to LF-5, LF-10 and PF, were Typic Kanhapludults or ultisols. Ashton & Hall (1992) reported three type of soils, namely ultisols, inceptisols and oxisols in their study area in Brunei and Sarawak which are located close to BRF (Figure 1).

Logging practices vary widely but in most rainforests they involve the selection extraction of only a proportion of the larger trees. The passage of tractors, skidders and other heavy machines scrapes off litter and compacts top soils, reducing their porosity, aeration and infiltration capacity (Hamilton 1985) and result in erosion as one of the most obvious physical evidence caused to logging in tropical lowland forests. Studies of erosion as a result of logging indicate that erosion increased during and after logging (Wyatt-Smith 1949, Liew 1974, Abdulhadi *et al.* 1981). Based on the observation (but not quantified study) during my study in the field, most erosion was mainly associated with roads and skid trails. Rates of recovery vary greatly, largely according to the intensity of disturbance. Badly damaged sites such as roads and landings appear to recuperate very slowly. Some have compact, bare and fragile soil surfaces for years after logging and traffic have ceased (Hamilton 1985).

According to Popenoe (1959), compared to logged forest, primary forest soils tend to have lower values for bulk density than soils that have been logged. There was limited evidence for this at BRF, where logging has significantly increased bulk density (Table 50 and 52). Results obtained from this research indicate, however, that the soil bulk density only slightly increases in the skid trail as compared to that of intact soils. This is to say that the effect of skid trails and intact soils on soil bulk density is not significance statistically at the same level of logging (Table 52). The trend of slightly increase in soil bulk density due to skidding activity was true for most cases, namely LF-5, LF-10, and LF-30 (no observation of skid trails was made in primary forest). The fact that average soil bulk density tend to increase in all sites (LF-5, LF-10, and LH-30) is proven to be artifact. Note that the three sites were scattered within the distance of ca 100 km. Variation in the soil bulk density corresponds to clay content of the soil under investigation. Naturally, the lower the clay content of soil, the higher the soil bulk density.

In general, soil bulk density found in the study area showed comparable values with that for oxisols reported by Unesco (1978). The significantly higher bulk density in LF-30 than in the other treatments is obviously related to a higher sand content (Table 54). It has been shown that bulk density is affected by the structure of soil, namely its looseness or degree of compaction, as well as by its swelling and shrinking characteristics, which are dependent upon clay content (Siregar 2004). For example, Ohta *et al.* (1996) reported bulk density values inversely correlated with clay content from a lowland dipterocarp forest of the Bukit Suharto Conservation Forest, East Kalimantan. A lower bulk density in finer soils at any depth may be attributed to better structural development.

Strongly weathered soil such as oxisols had undergone a high rate of physical and chemical weathering under the constantly warm and humid tropical climate. These soils consist primarily of kaolinite, a highly weathered clay mineral that is composed mainly of silica, aluminum, hydrogen and oxygen (Sanchez 1976). Consequently, these soil types bear a considerably low potential for adsorbing nutrients and releasing soil nutrients through mineral weathering (Siregar 2004). This low fertility level is strongly indicated by the low level of soil cation exchange capacity (CEC) in the study area which ranged from 6.51 to 16.94 me/100g at 0-10 cm depth. According to Cunningham (1963), CEC was playing an important role. The drop in CEC releases nutrients into soil solution, where they are subject to loss through leaching and surface runoff. CEC of skid trail samples decreased with increasing logging age. Meanwhile, CEC in intact soil in logged forest was lower than CEC of PF; the exception is CEC in LF-5 was higher than CEC in PF (Table 54).

The values of CEC in the study area were similar with CEC in Bukit Belalong (Pendry 1994); Danum Valley, Sabah (Newbery 1994 *in* Pendry 1994), and Dipterocarp regosol, podzol 1 and podzol 2 in Mulu Sarawak (Tie *et al.* 1979). However, compared with soil properties in other tropical rainforest, soil in primary forest in BRF was relatively lower in CEC than those in Sarawak and Sabah and this indicate strongly of low fertility level (Siregar 2004; Table 57).

Tropical soils are usually regarded as leached, acidic and nutrient poor (Whitmore 1984; Riswan 1981). This was the case at BRF where soils were acidic and low in nutrients (Table 54) and Al^{3+} was the dominant cation in the soil solution, similarly to other soils in tropical rainforest in Kalimantan (e.g. Prajadinata 1996). High Al^{3+} concentration facilitates the immobilization of phosphorus and is antagonistic to the uptake of the basic cations. It is also moderately toxic in its own right to a wide range of plants. These effects are most acute in the kaolisols, some acid sulphate soils and some limestone oxidic clays. In soils without significant sources of aluminum in their parent materials, such as podzols, peats and some acid sulphate soils, acid

Table 57. Soil chemical characteristics of some primary lowland tropical rainforest in Borneo

Location	Sample depth (cm)	n	pH	Total N (mg g-1)	Total P (mg g-1) (* ppm)	Exchangeable cations (mequiv kg-1)						Base Saturation (%)	CEC (me/100g)
						K	Na	Ca	Mg	Al	H		
BRF Cifor, East Kalimantan													
Primary Forest[1]	0-10	20	4.1	0.16	11.83*	0.23	0.07	0.28	0.57	6.81	0.68	11.16	10.1
Logged Forest-5[1]	0-10	40	4.2	0.16	6.37*	0.15	0.08	0.77	0.42	11.21	0.9	11.82	16.9
Logged Forest-10[1]	0-10	40	4.4	0.14	8.6*	0.15	0.07	1.13	0.37	4.23	0.33	19.08	9.5
Logged Forest-30[1]	0-10	40	4.1	0.09	6.51*	0.12	0.05	0.98	0.31	5.41	0.42	21.53	6.5
RIL, BRF, CIFOR[2]	0-3	1	3.8	0.45	-	0.23	0	0.17	0.23	6.19	1.17	2	26.8
CL, BRF, CIFOR[2]	0-30	1	4.4	0.08	-	0.04	0	0.1	0.07	3.94	0.28	3	8.3
Barito Ulu, Central Kalimantan[3]	0-10	-	3.2	0.95	0.04	0.14	0.01	0.1	0.24	9.07	0.08	9.67	5.4
Brunei, Belalong, 200m asl[4]	0-5	30	4	3.6	0.37	3.17	3.71	5.92	0.73	-	-	-	10.6
Brunei, Belalong, 500m asl[4]	0.5	30	3.8	4.6	0.37	3.25	1.03	6.11	1.11	-	-	-	14.0
Brunei, Belalong[5]	13	6	4.4	2.9	0.24	2.1	1.4	-	-	-	-	-	-
Brunei, Belalong[6]	0-5	10	3.7	3.7	0.42	3.4	2	8.4	0.20	-	-	-	-
Brunei, Belalong[6]	0-5	10	4.1	-	-	-	-	-	-	-	-	-	-
Brunei, Belalong[6]	0-5	10	4.6	2.6	0.27	2.2	0.5	1.8	0.30	-	-	-	-
Brunei, Andalau, Valley Site[5]	0-1	2	3.8	5.1	0.06	2	2	-	-	-	-	-	-
Sabah, Danum[7]	0-8	30	-	3.9	0.21	2.38	0.12	0.41	-	-	-	-	-
Sabah, Danum[8]	0-15	72	4.3	1.3	0.28	2.41	3..92	5.4	0.36	-	-	-	15.4
Sabah, Danum[9]	0-10	160	-	-	0.36	2.27	-	3.67	-	-	-	-	-
Sabah, Silam,280m asl[12]	0-15	20	5.7	-	-	1.4	77	246	1.0	-	-	-	49.0
Sabah, Silam,330m asl[12]	0-15	20	5.8	-	-	1.7	23	157	1.3	-	-	-	61.0
Sabah, Silam,480m asl[12]	0-15	20	6.1	-	-	2.3	42	115	0.60	-	-	-	8.8
Sarawak Mulu, Dipterocarp[10]	0-10	25	4.1	5.1	0.12	2.5	0.39	1.8	0.59	-	-	-	37.0
Sarawak Mulu, Dipterocarp, regoso[11]	0-12	1	4	2.4	0.12	1	5.2	0.8	0.40	-	-	-	16.4
Sarawak Mulu, Dipterocarp, podzo[11]	0-5	1	-	1.9	0.12	0.8	5.6	0.1	2.70	-	-	-	9.8
Sarawak Mulu, Dipterocarp, podzo[12]	0-6	1	4.8	2.7	0.11	1	5.2	0.7	0.50	-	-	-	14.0

1, This study; 2, Siregar (2004), 3, Prajadinata (1996); 4, Pendry (1994); 5, Ashton (1964); 6, Poulsen (1994); 7, Burghouts (1993); 8, D.M. Newbery *in* Pendry (1994); 9, Green (1992); 10, Proctor *et al* (1983); 11, Tie *et al* (1979); 12, Proctor *et al* (1988).

toxicity is mostly due to the direct activity of hydrogen ions (Rorison 1973), but there may also be specific effects by some organic acids. The changes in soil chemical characteristics that occurred after logging at skid trail and intact soil is not evident.

Soil in the study area has a low capacity in adsorbing nutrients. This low fertility level is strongly indicated by low level of soil cation exchange capacity. Thus, it has a low content of nutrients. As reported by Ashton & Hall (1992), the standing volume and net volume increment in mixed dipterocarp forest of north-western Borneo were dominated by the mature phase but soil nutrients probably influenced volume in the building phase. Moreover, the above source reported, mean proportional diameter increments of large trees were not correlated with measured soil nutrients but mean proportional diameter increment of recruits were correlated with measured soil nutrients. It can be concluded that the population of trees was not affected by soil nutrients.

Fertility evaluation

Fertility is a dynamic condition that determines how well the soil will support plant growth (Sumner 2000). All research sites unsurprisingly have low to very low fertility. This is determind mostly by low CEC or base saturation (Table 55). Our finding is in accordance with a report by Basuki & Sheil (2005) that describes the low fertility of Bulungan soil. Logging activities reduce soil fertility of inherently infertile forest soil in Bulungan by reducing the availability of P_2O_5 and K.

In general, the samples are acidic. According to Hardjowigeno (1987), such acidity tends to immobilize “macro” nutrients (e.g. nitrogen, phosphorus, potassium, calcium, magnesium and sulphur which are required in quite significant quantities by plants). In contrast, "micro" nutrient solubility (i.e. iron, manganese, zinc, copper and cobalt, which are only required in very low amounts) tend to be relatively high but leaching depletes some of these nutrients. Dissolved aluminum, and sometimes manganese (depending on mineral composition), can reach levels toxic to crops. Agriculture generally requires more neutral pH levels than we recorded. The forest vegetation is better adapted to these conditions.

Given widespread poor fertility, it would be very important to maintain the actual forest cover and to prevent any idea of clearing the vegetation. Since the region has high rainfall, clearing the vegetation cover would decrease the soil quality very quickly mainly by leaching and erosion processes and degrade the water quality of the surrounding drainage system.

Land evaluation for cropping alternatives

Evaluation of land capacity of the BRF plots resulted in Suitable (S2), Marginal (S3) to Not Suitable (N) class. Candlenut and peanut are not suitable over the research area because of the high rainfall. Several sites are suitable only for coconut cropping (Table 56).

No clear difference was found in the suitability of forest types for crops. Inherent limited soil fertility and the physical inhibition of sustainable production of plantation crops, e.g. steep slopes, tend to account for this. High rainfall, quick drainage, too fine texture and shallow soil depth of the research area are the factors that inhibit the suitability of these areas for agricultural crops.

Both primary and logged over forest areas are marginal or not suitable for sustained production of non-forest vegetation. This suggests that forest vegetation should always be the main coverage of the area as it is the only reasonable choice for land utilization.

CHAPTER 6. GENERAL DISCUSSION AND CONCLUSIONS

Floristic richness and stand structure after logging

Logging activity is a main disturbance on tropical rain forests in Indonesia, especially in Kalimantan. This activity has caused a lack of plant biodiversity in primary forest. This study showed some decreases of shared species in Logged Forest (LF)-5, LF-10, and LF-30 compared to Primary Forest (PF). The percentages of shared species between LF-5, LF-10 and LF-30 were 49.3%, 39.7% and 40.7% to PF (Table 8). Beside the reduction of plant biodiversity numbers, a difference in species domination between logged forest and primary forest has also taken place. Species such as *Mangifera swintoniodes* and *Hopea ferruginea* dominated primary forest, while *Macaranga pearsonii*, *Hopea dryobalanoides* and *Macaranga hypoleuca* dominated in the logged forest.

The similarity value among forest types depends on the tree diversities. Data from this study showed a low similarity index namely 0.215 from Jaccard index and 0.353 from Sorensen index. This can be caused from the lack of shared species between each forest type (Table 8) and low value of species diversity (H' = 1.894 to 2.066) among forest types.

This study found that family of Dipterocarpaceae and Euphorbiaceae are the most dominant families, contributing large component of the forest community in each stratum (Table 12); this is an aspect that needs special attention is their specificity on certain habitat after disturbance (Table 23) and their potential to be a good model in giving value of the forest ecosystem as a whole. Domination by these two families is caused by their sensitivity towards environmental change (Andersen 1997). One of the changes is by logging activities. This indication has also been explained by Widodo *et al*. (2004), who showed that loss of canopy layer in the primary forest will directly impact the forest biodiversity. Studying the sustainability of plant diversity, in particular related to forest extraction in the tropics, has been extremely difficult because of the unavailability of logging techniques and standard devices in each ecological sites (e.g. Kartawinata *et al.* (1981), Sist & Saridan (1999), Riswan (1987), Wyatt-Smith (1966), Wilkie *et al.* (2004)). Thus, collections of plants were made in 16 1-ha plot following the standard of Alder & Synnott (1992), Dallmeier (1992) and Sheil (1998). Results of replicated samplings in the Bulungan Research Forest (BRF) showed that sampling efficiency's percentage of observed versus expected species were less significantly varied between forest types and estimators.

The distribution of class diameter showed no indication of changing stand structure (Table 21). In healthy primary forest ecosystem, the stand structure contains different classes of diameter at all stages of growth namely seedling, sapling, pole and tree. As for LF-30, floristic composition and stand structure had a good quality. Similarly, the number of trees in older logged forest were more numerous than in newly logged forest (Soedirman 1993).

Basal area in LF-30 has approached the value of basal area in PF, which indicated the initial recovery of forest productivity after 30 years of logging. This enhancement of basal area has been stimulated by the large size of trees growing space, an impact of the logging activities, which then also affected a larger growth of trees diameter.

Coarse Woody Debris (CWD)

Coarse woody debris in research plot of PF is 270 m^3/ha or 10 times bigger than in old tropical forest in La Selva, Costa Rica. In the location, many CWD was found with crowns and residual boles of felled trees. This is consistent with the findings of Clark *et al*. (2002), who found that 30% of the logged forest was covered by the crowns and residual boles of felled trees. The amounts of biomass and inputs from residual trees in tropical rain forest are poorly documented and the causes for their variation at landscapes scales has not been studied. CWD itself is defined as a habitat for wildlife (Snowman 2004) and result of tree death, and it persists for some time following natural disturbances or forest harvesting (Parminter 2002). CWD can be rotting logs and stumps that provide habitat for plants, animals and insects as well as source of nutrients for soil development. As for Stevens (1997) decaying wood also supports a range of bryophytes and fungi.

CWD management in Indonesia has not been implemented in a large scale, whereas CWD is one of the important components that mainly contribute for biodiversity conservation programme (Proulx & Kariz 2002). For larger improvement of CWD development in Indonesia, an implementation of research, strategic higher level wildlife objectives and stand level wildlife objectives will be required.

Regeneration of seedlings and saplings

Table 39 showed an interesting result on seedlings and saplings regeneration where saplings densities on logged forest are lower than primary forest, while Table 35 showed a higher seedlings density on logged forest compared to primary forest. For saplings in particular, this may be caused by logging damage and low number of seedlings which, combined with logging perturbation, resulted in a net decrease in sapling recruitment while logging activities occurred. As for seedlings, it may have occurred due to the canopy opening in logged forest that stimulated the growth of seedlings. Other research in Peninsular Malaysia showed that the mean basal area and the density of tree seedlings and saplings with dbh < 5 cm was reduced by 150% of the original stand after logging in one compartment whilst in another compartment was increased up to 24%. Moreover, there is no change in species composition both before and after logging (Seng *et al.* 2004).

Research in Kibale National Park in Uganda tends to achieve the same result with the one in Peninsular Malaysia, where there are no differences on density nor species richness of seedlings before and after logging (Chapman & Chapman 1997). Related to both researches, the result in BRF showed that there was a difference on number of seedlings in logged forest with primary forest, where the number of seedlings was reduced in LF-10 compared to PF but larger number of seedlings were found in LF-5 and LF-30 than in PF.

Seedlings of *Hopea dryobalanoides* were dominant in PF, LF-5 and LF-30. This fact indicated that the future harvesting may be dominated by timber of the family Dipterocarpaceae, especially *Hopea dryobalanoides*.

Canopy opening at the research location of logged forest stimulated the early growth stage of Dipterocarpaceae. It can be shown by Tables 38 and 40 that the Dipterocarpaceae regeneration is still better than the other family. Therefore, Dipterocarpaceae is a prospective family to be harvested in the future. Beside its dominance in BRF and Kalimantan, another point that needed to pay attention is local species existence and their limited distribution due to their sensitivity towards logging activities (Slik *et al*. 2002).

Soils and vegetation

Soils and vegetation have a strong bond in which soil development is influenced by vegetation and the floristic composition of forest types is related to the soils (e.g. heath forest on spodsols vs. tall lowland evergreen forest on ultisols and oxisols). However, this study showed that the relation is not significant between the similarity index (C) and the distance between forest types (Table 8). It can be seen from the correlation value of Jaccard index where r = 0.023 and Sorensen index where r = 0.031. This fact is the same with the statement from Luizao (1995) and Primack *et al.* (1987) that said soil factors had only limited links to species composition.

In general, the research showed that bulk density on logged forest is higher than bulk density on primary forest as described in Table 52 and Table 54. This condition is supported by Popenoe (1959) which mentioned that primary forest soils tend to have lower values for bulk density than soils that have been logged. The increase of bulk density is caused by logging mechanism activities and the higher sand content of the soils especially in LF-30 in Table 54. Siregar (2004) said that bulk density is affected by the structure of soil, such as its looseness or degree of compaction, as well as by its swelling and shrinking characteristics, which are dependent upon clay content.

Compared with other research sites, the value of CEC in this research site is lower than in Sarawak (Tie *et al.* 1979) and Danum Valley, Sabah (Newberry 1994).

The low value of CEC in Table 54 and Table 57 indicated the low of soil fertility in the study area (Siregar 2004).

Soil chemical properties are dependent on soil physical properties (Siregar 2006, pers.comm.) where the initial physical nature of the soil derived from its parent material. Thus, a change in the soil physical and chemical properties due to logging activities will influence the species existence in a particular forest types.

Fertility and land evaluation for cropping alternatives

The soil fertility category of land at the research location ranged from low to very low (Table 55). The low soil fertility such the low P_2O_5 and K contents can be caused by the logging activities. The analysis of soil fertility is similar to that of Basuki and Sheil (2005).

Land condition in the research sites seemed not to suit the farming activities that occurred there due to some limiting factors, such as high precipitation, rapid drainage, and shallow soil depth (Table 56). With the consideration on low fertility of soil and unmatched condition between land and farming activities, forest existence should be prevented.

Forest management in Indonesia

Tropical rain forest development must be conducted with high awareness because the ecosystems are decreasing fast and the loss of biodiversity (MacKinnon *et al.* 1996). Depletion of genetic resource and the loss of species diversity are two of many impact of forest misuse. (Ewel & Conde 1980, Jacobs 1980 *in* Kartawinata *et al.* 2001). Selective logging creams off the best trees of commercial species, especially those from Dipterocarps family.

This issue has given a great concern in the importance of conservation of tropical rain forests. Vegetation analyses in the study sites indicated significant relation between logging and an increase in under storey vegetation density relative to primary forest. Studies in other places also proved that other animals are responsive to the alteration of physical and chemical environment (Putz 1994). However, results of this study showed logging operation in primary forest did not dramatically decreased the total species number and overall abundance of plants, but species composition in the logged forests was different compared to the primary forest.

The maximum yield of a forest stand is usually determined by the maximum basal area, which in a tropical mixed forest is likely to be in the range of 45-55 m^2/ha (Assmann 1970; Alder & Synnott 1992). Riswan & Kartawinata (1998a) reported that without additional disturbance, the recovery time is estimated to be more than 150 years for LF in order to develop into forest that is similar in structure to the original type through succession. In this study, both basal area and the number of stems with a dbh > 50cm were similar between PF and LF-30, while the data showed that LF-30 is dominated by commercial species of Dipterocarpaceae.

Twenty five trees with dbh of 20-49 cm is also more than enough to be chosen for nucleus trees as required in the TPTI system. Thus, to the TPTI system, LF-30 is mature enough for a second harvest in 5 years time as this system uses a 35-year harvest cycle. However, the time duration for tropical forest to reach the dynamic equilibrium through successional processes is still unknown. The absence of annual rings and differences in growth rates between PF and LF tree species make the estimation of time scale difficult. Although trees over 50 cm dbh are large enough to be cut, some may be relatively young and may have never reached the flowering stage, especially for dipterocarp species, which flowered and fruited irregularly (Kartawinata *et al.* 1981). Therefore, a 35-year cutting cycle may not give opportunities to many dipterocarps of sufficient girth to be cut for the second cutting period for their reproductive contribution to future harvest regeneration.

It consists of mixed species having a stratified structure and it regenerates naturally. The dominant Dipterocarpaceae species flower periodically ranging from three to ten years (Manan 1993). Thus, the selection of an appropriate silvicultural system in forest management is a crucial factor for the success of sustained yield production.

The Indonesian Selective Cutting and Replanting (TPTI) system or formerly known as Indonesian Selective Cutting (TPI) was proposed by the Government of Indonesia as a viable system which comprises logging practice with diameter limit and forest regeneration. TPTI system has been considered as the most appropriate system in terms of economy, ecology and technology to be used in tropical rain forest or other tropical forests in Indonesia.

Although the TPTI system can lead to sustainable management if properly applied and monitored (Manan 1993), according to the study in the field, and also as reported by many scientists such as MacKinnon *et al.* (1996) from other parts of Kalimantan, this system can not be implemented properly. If the government decides to do the second harvest of LF-30 forest, many risks will be taken. Mismanagement of the forest resource like this will lead to the potential loss or degradation of genetic resources and the possibility that many species still unknown to science can be lost forever.

A solution has to be found for this problem. Based on the data from this study, the TPTI system can be implemented with some modifications, such as: (1) the harvest cycle need to be changed from 35 years to 45 years after logging to give more time to the damaged forest after logging to a better recover; (2) Ten healthy trees of dbh > 100 cm should be left for seed production and long-term regeneration; (3) only slopes less than 30% or 27^0 can be extracted; and (4) slashing all undergrowth and climbers has to be re-evaluated. Although slashing activities strive for encouraging regeneration, it also eliminates many useful varieties of plant species such as rattan and other climber species (Appendix 13) and also tree seedlings as also reported by Sheil & van Heist (2000).

Conclusions

The tree species composition happened to decrease among logged forest compared to primary forest. Although total numbers of species in logged forest was increased, its shared species tend to decrease more than the one in primary forest. Stem density and basal area has a higher increase in logged forest. On LF-30, its stem density and basal area has approach the condition in PF. CWD ground on logged forest rise more than CWD in PF, while CWD standing on the contrary tend to decrease on the logged forest than on PF.

Numbers of seedlings tend to be higher in the logged forest, while numbers of saplings tend to take more places in primary forest. This condition may occur because of the canopy opening due to the logging activities that can stimulate seedlings growth. Conversely, in this study, it was found that the impact of logging activities can reduce the existing numbers of saplings while numbers of seedlings when the logging activities occurred are very low. Thus, the potential for seedlings to reach saplings stage also became low. In the end, numbers of saplings in logged forest will be lower than in the primary forest.

In general, the study showed no significant differences on the physical and chemical properties of soil due to the skid trail effect and intact soil on the same logging age plot. On the contrary, in the different logging age plot, there has been a difference on the physical and chemical soil properties due to the skid trail and intact soil effect described on Tables 52 and 53. The significant differences were most likely caused by the types of soil that by natural is not alike with the forest type.

Soil fertility and land cover analysis showed that land on the study site did not suit farming activities. Therefore, forest existence and condition need to be prevented. If the land is force to be use for farming activities, the risk for land recovery will take place in a higher level and forest conservation will also need to be conducted in a longer period.

According to TPTI system, LF-30 is mature enough for a second harvest, however, result from this study indicated that 35 years cutting cycle might not give opportunities to some species, despite their large size, to make sufficient reproductive contribution to ensure the quality of future harvest regeneration. TPTI's system may also need to be revised to ensure long-term forest productivity in terms of not only timber but other goods and ecosystem services, the value of which are not quantified in monetary terms, but can be higher than the timber revenue.

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Appendix 1. Tree species composition in a four 1-ha plots in primary and logged lowland forests in the Bulungan Research Forest-CIFOR, East Kalimantan.

Family	Species Name	PF	LF-5	LF-10	LF-30	Total
Alangiaceae	*Alangium javanicum (Blume) Wangerin*	11	1	6	6	24
	Alangium longiflorum Merrill			1		1
	Alangium ridleyi King				3	3
Anacardiaceae	*Buchanania arborescens F. Muell.*	1	1	1		3
	Buchanania sessifolia Blume		10	4		14
	Campnosperma auriculata Hook. f.			3	1	4
	Dracontomelon dao Merrill & Rolfe			1	4	5
	Drimycarpus luridus (Hook.f.) Ding Hou	1	2	2		5
	Drimycarpus sp.				1	1
	Gluta macrocarpa (Engl.) Ding Hou			1	5	6
	Gluta wallichii (Hook. f.) Ding Hou	40	27	13	4	84
	Koordersiodendron pinnatum Merrill	2	2		7	11
	Mangifera foetida Lour.				2	2
	Mangifera macrocarpa Blume				1	1
	Mangifera magnifica K. M. Kochummen		1			1
	Mangifera pajang Kosterm.				1	1
	Mangifera sp. 1		1			1
	Mangifera sp. 2	1				1
	Mangifera swintoniodes Kosterm	76	22	1		99
	Mangifera torquenda A. J. G. H. Kosterm	8				8
	Melanochyla auriculata Hook. f.			1		1
	Melanochyla beccariana Oliver	1	1			2

	Melanochyla bullata Ding Hou		2			2
	Melanochyla caesia (BL.) Ding Hou		3			3
	Melanochyla elmeri Merrill	6				6
	Melanochyla fulvinervia (Blume) Ding Hou				1	1
	Melanochyla sp.			1	7	8
	Melanochyla sp.1		2	1		3
	Melanochyla sp.2			3		3
	Melanochyla sp.3				1	1
	Melanochyla sp.4				6	6
	Parishia insignis Hook.f.				1	1
	Semecarpus burburyanus Gibbs				1	1
	Semecarpus sp.				2	2
	Swintonia glauca Engl.		16			16
Annonaceae	*Anaxagorea ramiflora Boerl.*		2			2
	cf. Mitrephora sp.				2	2
	cf. Orophea sp.				2	2
	cf. Phaeanthus sp.				10	10
	Cyathocalyx bancanus Boerl.		4			4
	Cyathocalyx carinatus (Ridley) J.Sincl.			2		2
	Cyathocalyx magnifica Diels	1				1
	Cyathocalyx sp.	1				1
	Cyathocalyx sumatrana Scheff.			4	4	8
	Enicosanthum paradoxum Becc.			1	1	2
	Enicosanthum sp.			1		1
	Goniothalamus sp.			1		1
	Mezzettia parviflora Becc.	3	5	1	4	13
	Mitrephora maingayi Hook. f. & Thoms.		2			2
	Monocarpia kalimantanensis P. J. A. Kessler				5	5
	Polyalthia cauliflora Hook.f. & Thoms.	17		2	7	26
	Polyalthia glauca Boerl.			1		1
	Polyalthia lateriflora King	3	6	2	1	12
	Polyalthia microtus Miq.				2	2
	Polyalthia rumphii Merrill	3		11	3	17
	Polyalthia sp.	3	4	1	3	11
	Polyalthia sp.1	2		4		6

	Polyalthia sp.2			1		1
	Polyalthia sp.3			2		2
	Polyalthia sp.4			1		1
	Polyalthia sp.5			1		1
	Polyalthia sp.6				2	2
	Polyalthia subcordata Blume		1			1
	Polyalthia sumatrana (Miq.) Kurz	15	9	15	2	41
	Popowia hirta Miq.		2			2
	Pseuduvaria cf. rugosa Merrill	2				2
	Pseuduvaria reticulata Miq.	1				1
	Sageraea elliptica Hook. f. & Thoms.		1			1
	Sageraea lanceolata Miq.	1	3		10	14
	Xylopia caudata Hook. f. & Thoms.		12			12
	Xylopia elliptica Maing. ex Hook. f.			2	2	4
	Xylopia ferruginea Baill.		2	1		3
	Xylopia malayana Hook.f. & Thoms.	1		2	9	12
	Xylopia sp.	1	2	1		4
Apocynaceae	*Alstonia iwahigensis Elmer*			1		1
	Alstonia sp.				3	3
	Alstonia spathulata Blume		1			1
	Apocynaceae		1			1
	Dyera costulata Hook. f.	1	3		6	10
	Kibatalia arborea G. Don		1			1
	Kibatalia flavida Blume				2	2
	Kibatalia maingayi (Hook. f.) R. E. Woodson		2			2
	Kibatalia villosa Rudjiman			1	1	2
	Tabernaemontana macrocarpa Korth. ex Blume			1		1
Aquifoliaceae	*Ilex cymosa Blume*				2	2
	Ilex sp. 1		1			1
	Ilex sp. 2	2				2
Bombacaceae	*Coelostegia chartacea Soeg. Reksod.*			3	1	4
	Coelostegia sp.			3		3
	Coelostegia sp. 1				3	3
	Durio acutifolius (Mast.) Kosterm.	3			2	5
	Durio dulcis Becc.			3	1	4

	Durio grandiflorus (Mast.) Kosterm. & Soeg.	4	3			7
	Durio graveolens Becc.		2	2		4
	Durio griffithii Bakh.	3		1	2	6
	Durio kutejensis Becc.			3	1	4
	Durio lanceolatus Mast.	6	6		2	14
	Durio oxleyanus Griff.	1		1		2
	Durio sp. 1		1			1
	Durio sp.2		7	1		8
	Durio testudinarius Becc.	2				2
	Neesia synandra Mast.	3	2	2	4	11
Burseraceae	*Canarium denticulatum Blume*			1		1
	Canarium hirsutum Willd.				8	8
	Canarium littorale Blume	6	14	1	1	22
	Canarium megalanthum Merrill				1	1
	Canarium odontophyllum Miq.	4		2	5	11
	Canarium pillosum A. W. Benn.	7	6			13
	Canarium sp.	3	2		1	6
	Canarium sp. 2				3	3
	Canarium sp.1			4		4
	Dacryodes costata (A. W. Benn.) H. J. Lam	2	5	3	1	11
	Dacryodes crassipes Kalkman		2			2
	Dacryodes incurvata (Engl.) H. J. Lam	35	11	2	12	60
	Dacryodes laxa (A. W. Benn.) H. J. Lam		2		2	4
	Dacryodes rostrata (Blume) H. J. Lam forma pubescens	15	27	14	17	73
	Dacryodes rubiginosa (A. W. Benn.) H. J. Lam		1			1
	Dacryodes rugosa (Blume) H.J. Lam	21	13	18	15	67
	Dacryodes sp.	1		1		2
	Santiria apiculata A.W.Benn.			2	3	5
	Santiria griffithii Engl.		4		1	5
	Santiria laevigata Blume	1		3		4
	Santiria oblongifolia Blume	2			3	5
	Santiria rubiginosa Blume		2			2
	Santiria sp.	1			2	3
	Santiria sp.1	1	3			4
	Santiria tomentosa Blume	5	1	1	3	10

	Triomma malaccensis Hook. f.				2	2
Caesalpiniaceae	*Crudia teniupes Merrill*			1		1
Caprifoliaceae	*Viburnum sp.*			2	1	3
Celastraceae	*Bhesa paniculata Arn.*	1	4	2		7
	Celastraceae			1		1
	Kokoona littoralis M. A. Laws.		1			1
	Kokoona reflexta (M. A. Lawson) Ding Hou	2			2	4
	Lophopetalum beccarianum Pierre	4				4
	Lophopetalum cf. glabrum Ding Hou				6	6
	Lophopetalum javanicum Turcz.				5	5
	Lophopetalum sp.				10	10
	Lophopetalum subobovatum King		9			9
Chrysobalanaceae	*Atuna excelsa (Jack) Kosterm.*	4	8			12
	Atuna racemosa Rafin.		1	1		2
	Atuna sp.				1	1
	Licania splendens (Korthals) Prance		2			2
	Parinari racemosum Merrill		1			1
Combretaceae	*Terminalia foetidissima Griff.*			1		1
	Terminalia sp. 1		1			1
	Terminalia subspathulata King			1		1
Cornaceae	*Ellipanthus tomentosus Kurz*			2	8	10
	Mastixia bracteata C. B. Clarke	1				1
	Mastixia rostrata Blume		1			1
	Mastixia sp.			3	1	4
	Mastixia trichotoma Blume	1	3			4
Crypteromiaceae	*Crypteronia macrophylla van Beusekom-Osinga*			1		1
Dilleniaceae	*Dillenia excelsa Martelli*	10	17	6	10	43
	Dillenia eximia Miq.		2			2
	Dillenia grandifolia Wall.		1			1
	Dillenia pentagyna Roxb.		4			4
	Dillenia reticulata King				1	1
Dipterocarpaceae	*Anisoptera costata Korth.*	2	1	1		4
	cf. Hopea sp.			4	4	8
	Dipterocarpus cornutus Dyer				1	1
	Dipterocarpus crinitus Dyer	3			12	15

Dipterocarpus elongatus Korth.	3	1			4
Dipterocarpus eurynchus Miq.	26		1	11	38
Dipterocarpus gracilis Blume	11				11
Dipterocarpus humeratus van Slooten			15	2	17
Dipterocarpus lowii Hook. f.		14			14
Dipterocarpus pachyphyllus Meyer	2			15	17
Dipterocarpus sp.	2		2	4	8
Dipterocarpus sp. 2				4	4
Dipterocarpus sp.1			20	1	21
Dipterocarpus stellatus Vesque	5	29	1		35
Dipterocarpus tempehes van Slooten			1		1
Dipterocarpus verrucosus Foxworthy ex. v. Slooten	1		1		2
Dryobalanops lanceolata Burck	23		21	3	47
Hopea cernua Teijsm. & Binn.			2		2
Hopea cf. obovoidea Sloot.	1				1
Hopea dryobalanoides Miq.		1	1	91	93
Hopea ferruginea Parijs	72	58			130
Hopea mengerawan Miq.	8				8
Hopea semicuneata Symington				10	10
Hopea sp.	1	1			2
Hopea sp. 1				2	2
Parashorea lucida Kurz				4	4
Parashorea malaanonan Merrill	28	27	20	36	111
Parashorea parvifolia Wyatt-Smith ex P. S. Ashton	15	1			16
Parashorea sp. 1		1			1
Parashorea tomentella (Symington) Meijer			5		5
Shorea agamii P. S. Ashton	17	2	1	16	36
Shorea angustifolia P. S. Ashton	47			55	102
Shorea atrinervosa Symington	6	3	5	3	17
Shorea beccarii Dyer ex Brandis	12	2		69	83
Shorea brunnescens P. S. Ashton		12			12
Shorea cf. almon Foxworthy			1		1
Shorea cf. atrinervosa Symington		1	8		9
Shorea cf. maxwelliana King	6	1			7
Shorea cf. obovoidea van Slooten	36				36

Shorea cf. ovalis Blume		1	1		2
Shorea elliptica Meijer	2	4			6
Shorea faguetiana Heim	10				10
Shorea fallax Meijer		11			11
Shorea hopeifolia (Heim) Symington	9	3	6	2	20
Shorea inappendiculata Burck	1		5		6
Shorea johorensis Foxworthy	14	5	14	24	57
Shorea laevifolia(Parijs) Endert		1			1
Shorea lamellata Foxworthy				3	3
Shorea leprosula Miq.	5	3	1	19	28
Shorea macrophylla (de Vriese) P. S. Ashton	1				1
Shorea macroptera Dyer	46	16	1	14	77
Shorea malaononan Blume		2			2
Shorea maxwelliana King	6	6			12
Shorea multiflora (Burck) Symington			5	9	14
Shorea ochracea Symington		3			3
Shorea ovalis Blume	12	9	9	16	46
Shorea parvifolia Dyer	72	79	78	36	265
Shorea parvistipulata Heim	11		8	7	26
Shorea patoienis P. S. Ashton				2	2
Shorea pauciflora King	21	9	2	3	35
Shorea pinanga Scheff.	42	3	15	28	88
Shorea seminis v. Slooten	3				3
Shorea smithiana Symington				2	2
Shorea sp.	15	10		5	30
Shorea sp. 4				2	2
Shorea sp. 5				7	7
Shorea sp. 6		1			1
Shorea sp.1		4	6		10
Shorea sp.2				20	20
Shorea sp.3		6			6
Shorea venulosa G. H. S. Wood ex Meijer		4			4
Shorea xanthophylla Symington	37	1			38
Vatica albiramis v. Slooten	10	8			18
Vatica granulata v. Slooten	43	1		1	45

	Vatica micrantha v. Slooten				30	30
	Vatica nitens King				1	1
	Vatica oblongifolia Hook.f.	9	7	1		17
	Vatica pauciflora Blume		1			1
	Vatica rassak Blume	1	2			3
	Vatica sarawakensis Heim			2	3	5
	Vatica sp.	3	1		2	6
	Vatica sp. 1		1	11	37	49
	Vatica umbonata Burck	31		4	16	51
	Vatica vinosa P.S. Ashton	27	3			30
Ebenaceae	*Diospyros cf. oblonga Wall.*	1	1			2
	Diospyros borneensis Hiern	3		1	10	14
	Diospyros buxifolia Hiern	25			4	29
	Diospyros cf. korthalsiana Hiern				1	1
	Diospyros cf. pendula Hasselt ex Hassk.				8	8
	Diospyros cf. perfida Bakh.	2				2
	Diospyros cf. sumatrana Miq.	4				4
	Diospyros curraniopsis Bakh.	3	3			6
	Diospyros diepenhorstii Miq.		2			2
	Diospyros elliptifolia Merrill	1				1
	Diospyros evena Bakh.		5			5
	Diospyros foxworthyii Bakh.	19				19
	Diospyros frutescens Blume	4	2	9	8	23
	Diospyros hallierii Bakh.	1				1
	Diospyros lanceaefolia Roxb.	2				2
	Diospyros levigata		2			2
	Diospyros macrophylla Blume			2		2
	Diospyros malayana Bakh.		2	1	2	5
	Diospyros oblonga Wall.	12	11			23
	Diospyros pendula Hasselt ex Hassk.				10	10
	Diospyros pilosanthera Blanco			3		3
	Diospyros polyalthioides Hiern				1	1
	Diospyros sp.	6	18	13	12	49
	Diospyros sp.1		14	10		24
	Diospyros sp.2				1	1

	Diospyros sp.3			2		2
	Diospyros sp.4			1	1	2
	Diospyros sp.5			1	3	4
	Diospyros sp.7				1	1
	Diospyros sp.8			4		4
	Diospyros sumatrana Miq.	29	7	10	7	53
	Diospyros toposoides King ex Gamble	1	1			2
	Diospyros wallichii King ex Gamble	1				1
Elaeocarpaceae	*Elaeocarpus cupreus Merrill*			1		1
	Elaeocarpus parvifolius Wall.	1				1
	Elaeocarpus pedunculatus Wall.		1			1
	Elaeocarpus sp.			2	1	3
	Elaeocarpus sp.1			1		1
	Elaeocarpus sp.2			1		1
	Sloanea javanica (Miq.) Koord. & Valeton	1		3	2	6
Euphorbiaceae	*Antidesma leucopodum Miq.*			2	3	5
	Antidesma neurocarpum Miq.				2	2
	Antidesma sp.			2		2
	Antidesma sp. 1		1			1
	Antidesma trunciflorum Merrill	8				8
	Aporosa benthamiana Hook. f.		1	1		2
	Aporosa confusa Gage				4	4
	Aporosa falcifera Hook. f.	7	2	6	3	18
	Aporosa grandistipula Merrill	1		3	1	5
	Aporosa lucida (Miq.) Airy Shaw	2				2
	Aporosa lunatum Kurz		1			1
	Aporosa nitida Merrill	5		3	3	11
	Aporosa prainianaKing ex Gage		2			2
	Aporosa sp.	1	5		1	7
	Aporosa subcaudata Merrill	7	6	4	1	18
	Baccaurea angulata Merrill		4			4
	Baccaurea bracteata Muell. Arg.	1				1
	Baccaurea edulis Merrill	7	13			20
	Baccaurea javanica Muell. Arg.	8	1			9
	Baccaurea kunstleri King ex Gage	2	3			5

Baccaurea macrocarpa Muell. Arg.	5	1	2	4	12
Baccaurea minor Hook. f.	13	3			16
Baccaurea odoratissima Elmer			2		2
Baccaurea pubera Muell. Arg.	3	1			4
Baccaurea pyriformis Gage			7	5	12
Baccaurea sp.	2	24	1	2	29
Baccaurea sp.1		2	4		6
Baccaurea stipulata J. J. Smith	7	1			8
Baccaurea sumatrana Muell. Arg.		22			22
Baccaurea tetandra Muell. Arg.			4		4
Baccaurea trunciflora Merrill			1		1
Blumeodendron calophyllum AiryShaw			1	4	5
Blumeodendron cf. tokbrai Kurz	4	5	1	1	11
Blumeodendron elateriospermum J. J. Smith	2				2
Bridelia glauca Blume			1		1
Castanocarpus sp.			1		1
Cephalomappa beccariana Baill.	14		2		16
Cephalomappa lepidotula Airy Shaw		7			7
Cephalomappa malloticarpa J. J. Smith		1		8	9
Chaethocarpus castanocarpus Thw.	2	13	2	2	19
Cleistanthus bakonensis Airy Shaw		15			15
Cleistanthus beccarianus Jablonszky			6		6
Cleistanthus myrianthus (Hassk.) Kurz	1	5	1	1	8
Cleistanthus sp.	1			1	2
Cleistanthus sumatranus Muell. Arg.				1	1
Coccoceras borneense J. J. Smith.	22				22
Croton argyratus Blume		16			16
Drypetes crassipes Pax & K. Hoffm.	4	1		11	16
Drypetes kikir Airy Shaw				14	14
Drypetes laevis Pax et Hoffm.	9	4			13
Drypetes longifolia Pax & K. Hoffm.	1		1		2
Drypetes oblongifolia (Bedd.) Airy Shaw	1		1	3	5
Drypetes polyneura Airy Shaw	9			6	15
Drypetes sp.		2		2	4
Elateriospermum tapos Blume	3	4	68	10	85

Glochidion arborescens Blume	1				1
Glochidion bakonensis		2			2
Glochidion borneensis Boerl.	1		1		2
Glochidion celastroides Pax		3			3
Glochidion cf. arborescens Blume		1			1
Glochidion obscurum Blume				6	6
Glochidion rubrum Blume			1	4	5
Glochidion sericeum Zoll. & Mor.			2		2
Glochidion sp.				3	3
Koilodepas brevipes Merr.		4			4
Koilodepas laevigatus Airy Shaw				47	47
Macaranga aetheadenia Airy Shaw	1		2		3
Macaranga bancana Muell. Arg.		1	103	1	105
Macaranga beccariana Merrill	1		13	5	19
Macaranga cf. hullettii King ex Hook.f.			6		6
Macaranga cf. indistincta T. C. Whitmore			7		7
Macaranga conifera (Zoll.) Muell. Arg.				52	52
Macaranga gigantea Muell. Arg.	3	33	16	17	69
Macaranga grandibracteolata Stuart J.Davies			3		3
Macaranga hosei King ex Hook.f.			28	3	31
Macaranga hypoleuca Muell. Arg.			142	84	226
Macaranga lamellata T. C. Whitemore			2		2
Macaranga lowii King ex Hook.f.	22	8	10	12	52
Macaranga motleyana Muell. Arg.		8		1	9
Macaranga pearsonii Merrill			226	3	229
Macaranga pruinosa Muell. Arg.		14	1		15
Macaranga repando-dentata Airy Shaw		1		11	12
Macaranga sp.		1			1
Macaranga winkleri Pax & K. Hoffm.		1	13		14
Mallotus eucaustus Airy Shaw	69	8		16	93
Mallotus griffthianus Hook. f.				4	4
Mallotus korthalsii Muell. Arg.	1				1
Mallotus macrostachyus Muell. Arg.			1		1
Mallotus moritzianus Muell. Arg.	2	6			8
Mallotus muticus (Muell. Arg.) Airy Shaw		3	9	1	13

	Mallotus peltatus Muell. Arg.	1				1
	Mallotus penangensis Muell. Arg.	20	27	25	17	89
	Mallotus sp.			1	1	2
	Mallotus subcaudatus		1			1
	Mallotus wrayi King ex Hook. f.			11	18	29
	Neoscortechinia kingii Pax & K. Hoffm.	3		1		4
	Neoscortechinia philippinensis (Merr.) P. C. Welzen			1		1
	Paracroton pendulus Miq.	6	2	12	10	30
	Phyllanthus emblica Linn.	1				1
	Pimelodendron griffithianum (Muell. Arg.) Hook. f.	12	6	6	15	39
	Pimelodendron papaveroides J. J. Smith		2			2
	Ptychopxis sp. 1		2			2
	Ptychopyxis arborea(Merrill) Airy Shaw	3	4			7
	Ptychopyxis bacciformis Croizat		3	4	3	10
	Ptychopyxis sp.	1	1	1	12	15
	Trigonopleura malayana Hook. f.	1	1			2
	Trigonostemon sp.		7			7
	Trigonostemon sp. 1		2			2
Fagaceae	*Castanopsis fulva Gamble*				3	3
	Castanopsis megacarpa Gamble			1		1
	Castanopsis motleyana King	1	6		3	10
	Castanopsis sp.	4				4
	Castanopsis sp. 1				1	1
	Castanopsis sp. 2				1	1
	Lithocarpus blumeanus Rehder		2			2
	Lithocarpus cantleyanus Rehder	1	6			7
	Lithocarpus conocarpa Rehder	4				4
	Lithocarpus cooperta Rehder				1	1
	Lithocarpus ewyckii Rehder	13	3			16
	Lithocarpus gracilis (Korth.) Soepadmo	1	10	3		14
	Lithocarpus lucidus Rehder		2			2
	Lithocarpus nieuwenhuisii (Seem) A. Camus		4			4
	Lithocarpus reflexus (King) A. Camus		3			3
	Lithocarpus sp.	3	1	2	5	11
	Lithocarpus sp.1		5	2	1	8

	Lithocarpus sp.2		1	3		4
	Lithocarpus sp.3			1		1
	Lithocarpus sp.4			3	1	4
	Lithocarpus sp.5			2		2
	Lithocarpus urceolaris (Jack) Merrill	3	1			4
	Quercus argentata Korth.	1			1	2
	Quercus gemelliflora Blume	2				2
	Quercus sp.	1			1	2
	Quercus sp. 1		1			1
Flacortiaceae	*Flacourtia rukam Zoll. & Mor.*		1			1
	Homalium grandiflorum Benth.		1			1
	Hydnocarpus borneensis Sleumer	4				4
	Hydnocarpus castanea Hook. f. et Thoms	1				1
	Hydnocarpus kuenstleri Warb.	7				7
	Hydnocarpus polypetalus (v.Slooten) Sleum.	7				7
	Hydnocarpus sp.	5				5
	Hydnocarpus sp. 3				3	3
	Hydnocarpus sp.1			19	2	21
	Hydnocarpus sp.2			1		1
	Hydnocarpus wodii Merrill	8				8
	Hydnocarpus wrayi King	1				1
	Ryparosa baccaureoides Sleum.	7				7
	Ryparosa hirsuta J. J. Smith		1			1
	Ryparosa kostermansii Sleum.			1		1
	Ryparosa sp.			1	1	2
Guttiferae	*Calophyllum cf. hosei Ridley*	5				5
	Calophyllum cf. lowii Planch. & Triana		18			18
	Calophyllum pulcherrimum Wall.	2	5			7
	Calophyllum sp.			2	1	3
	Calophyllum sp. 3				1	1
	Calophyllum sp. 4				3	3
	Calophyllum sp.1	2		1		3
	Calophyllum sp.2			1		1
	Calophyllum venulosum Zoll.	1		1		2
	Garcinia bancana (Miq.) Miq.		4			4

	Garcinia celebica L.	1				1
	Garcinia cf. griffithii T. Anders		2		1	3
	Garcinia dioica Blume	1				1
	Garcinia gaudichaudii Planch. & Triana	1	3			4
	Garcinia macrophylla Miq.	1	1			2
	Garcinia nervosa Miq.	4	1			5
	Garcinia parvifolia Miq.	10	3	4		17
	Garcinia penangiana Pierre	3				3
	Garcinia rostrata Hort. ex Boerl.	2				2
	Garcinia sp.		5	2	3	10
	Garcinia sp. 5				4	4
	Garcinia sp.1		3	1	1	5
	Garcinia sp.2		2	2	3	7
	Garcinia sp.3		2	1	2	5
	Garcinia sp.4			3		3
	Kayea borneensis P. F. Stevens	1				1
	Mesua borneensis P.F. Stevens	1	12			13
	Mesua cf. conooidea			1		1
	Mesua sp.			2		2
	Mesua sp.1				1	1
Hypericaceae	*Cratoxylum arborescens Blume*		1			1
	Cratoxylum formosum Benth. & Hook. f. ex Dyer			1		1
	Cratoxylum sumatranum Blume	1			1	2
Icacinaceae	*Stemonurus grandifolius Becc.*		1	1		2
	Stemonurus macrophyllus Blume		2			2
	Stemonurus scorpioides Becc.				3	3
	Stemonurus scundiflorus Blume	4	3			7
	Stemonurus sp.			2	8	10
	Stemonurus umbellatus Becc.				1	1
Lauraceae	*Actinodaphne glabra Blume*		2	1		3
	Alseodaphne elliptica		2			2
	Alseodaphne elmeri Merrill			1	4	5
	Alseodaphne glabra Blume				3	3
	Alseodaphne glomerata Nees		1			1
	Alseodaphne peduncularis Hook. f.			1	2	3

Alseodaphne sp.			4	4	8
Alseodaphne sp. 1		4	2	9	15
Alseodaphne sp.2			1		1
Alseodaphne sp.3			2		2
Alseodaphne umbelliflora Hook. f.	2				2
Alseodaphne untrinerved		1			1
Beilschmiedia glabra Kosterm.	1				1
Beilschmiedia madang Blume	2	4			6
Beilschmiedia sp.		2	1	10	13
Beilschmiedia sp.1			1		1
cf. Alseodaphne sp.				1	1
Cinnamomum inners Reinw. Ex Blume	2				2
Cinnamomum javanicum Blume		1			1
Cryptocarya impressa Miq.	1				1
Cryptocarya crassinervia Miq.		3		1	4
Cryptocarya ferrea Blume	5				5
Cryptocarya sp.			2	2	4
Cryptocarya sp. 4				1	1
Cryptocarya sp.1			1		1
Cryptocarya sp.2			1		1
Cryptocarya sp.3			1		1
Cryptocarya tomentosa Blume		3			3
Dehaasia elliptica Ridley	3				3
Dehaasia firma Blume	2	13			15
Dehaasia incrassata (Jack.) Kosterm.		1			1
Dehaasia sp.1			2	1	3
Dehaasia tomentosa Blume		1			1
Endiandra elongata Arifiani	1		1		2
Endiandra kingiana Gamble			3		3
Endiandra rubescens Blume ex Miq.	1	3			4
Endiandra sp.	1				1
Eusideroxylon zwageri Teijsm. & Binn.	1		28	11	40
Lauraceae	2		1	3	6
Litsea angulata Blume	1				1
Litsea ferruginea Blume			1		1

	Litsea firma Hook. F.		3			3
	Litsea lanceifolia Hook. f.	1				1
	Litsea machilifolia Gamble		3			3
	Litsea noronhae Bl.	1				1
	Litsea oppositifolia L.S. Gibbs				3	3
	Litsea sessilis Boerl.		4			4
	Litsea sp.		4	1	6	11
	Litsea sp. 1		4			4
	Neolitsea sp.		1	1	2	4
	Nothaphoebe panduriformis Gamble			1		1
	Phoebe elliptica Blume		1			1
	Phoebe grandis (Nees.) Merrill		1			1
	Phoebe sp.		1			1
Lecythidaceae	*Barringtonia macrostachya Kurz*	1	10	1	5	17
	Barringtonia sp.	1				1
Leguminosae	*Afzelia rhamboidea F. Villar*				2	2
	Aganope sp.				2	2
	Archidendron ellipticum (Bl.) Nielsen		2			2
	Archidendron microcarpum (Bentham) I. Nielsen		1			1
	Archidendron sp.			1	3	4
	Archidendron sp. 1		1			1
	Cynometra ramiflora Miq.	5		8	4	17
	Cynometra sp. 1		8			8
	Dialium indum Linn	2	8	8	5	23
	Dialium kunstleri Prain				39	39
	Dialium maingayi		8			8
	Dialium modestum (v. Steenis) Steyaert.	2	1			3
	Dialium patens Baker	6				6
	Dialium platysepalum Baker	10		4	7	21
	Dialium sp.	2	1			3
	Fabaceae		1			1
	Fordia splendidissima (Blume ex Miq.) J. R. M. Buijsen			7		7
	Koompassia excelsa Taub.		1	4		5
	Koompassia malaccensis Maing.	10	4	5	7	26
	Parkia speciosa Hassk.	1	1	8	1	11

	Parkia timoriana Merrill				1	1
	Saraca declinata Miq.	3			3	6
	Saraca sp.				2	2
	Sindora leiocarpa Baker ex K.Heyne	2	9	4	2	17
	Sindora wallichii Benth.			3	2	5
Linaceae	*Ctenolophon parvifolius Oliver*	1	7			8
Loganiaceae	*Fagraea sp.*	1				1
Magnoliaceae	*Elmerillia tsiampacca (L.) Dandy*		1			1
	Magnolia candollii (Blume) H. P. Nooteboom	1	1	1	2	5
	Magnolia gigantifolia (Miq.) H. P. Nooteboom	8	6		1	15
	Magnolia lasia H. P. Noot.eboom			6	7	13
	Magnolia sp.			1		1
Melastomataceae	*Memecylon myrsinoides Blume*		1			1
	Memecylon borneense Merrill				1	1
	Memecylon costatum Miq.	3	2			5
	Memecylon edule Roxb.	3	6	1	8	18
	Memecylon floribundum Benth.		1			1
	Memecylon laurinum Blume	4				4
	Memecylon myrsinoides Blume		5			5
	Memecylon paniculatum Jack		2			2
	Memecylon sp.		5		2	7
	Pternandra azurea (Bl.) Burkill				1	1
	Pternandra caerulescens Jack	3	1	2	3	9
	pternandra galeata Ridley		3			3
	Pternandra rostrata (Cogn.) M. P. Nayar	21	17	1		39
	Pternandra sp.				1	1
Meliaceae	*Aglaia argentea Blume*			1		1
	Aglaia crassinervia Kurz ex Hiern			1	2	3
	Aglaia gigantea Pellegrin			1		1
	Aglaia leptantha Miq.		1		1	2
	Aglaia leucophylla King	2				2
	Aglaia macrocarpa (Miq.) C.M. Pannell	1				1
	Aglaia oligophylla Miq.	1	1			2
	Aglaia rubiginosa (Hiern.) C. M. Pannell		3			3
	Aglaia silvestris Merrill		1			1

	Aglaia simplicifolia Harms.	3				3
	Aglaia sp.	7	4	10	6	27
	Aglaia sp. 3			4	6	10
	Aglaia sp. 6			1	3	4
	Aglaia sp. 7				1	1
	Aglaia sp. 8				1	1
	Aglaia sp.1	1		2		3
	Aglaia sp.2			1		1
	Aglaia sp.4			2		2
	Aglaia sp.5			3		3
	Aglaia spectabilis (Miq.) S. S. Jain & S. S. R. Bennet				1	1
	Aglaia tomentosa Teijsm. & Binn.	3		2	4	9
	Chisocheton ceramicus Miq.				1	1
	Chisocheton macrophyllus King	2		1		3
	Chisocheton patens Blume	2	3	3		8
	Chisocheton pentandrus Merrill			2		2
	Chisocheton sp.			6	4	10
	Dysoxylum alliaceum Blume	1				1
	Dysoxylum sp.		3	3	1	7
	Dysoxylum sp.1		1	1	1	3
	Dysoxylum sp.2			3		3
	Reinwardtiodendron humile (Hassk.) D. J. Mabberley	1			1	2
	Sandoricum emarginatum Hiern		1			1
	Sandoricum koetjape Merrill				1	1
	Sandoricum sp.			1		1
	Walsura pinnata Hassk			4	1	5
	Walsura sp.			1	1	2
	Walsura sp.1			1		1
Moraceae	*Artocarpus anisophylla Miq.*		5			5
	Artocarpus dadah Miq.				3	3
	Artocarpus elasticus Reinw	2	4	2	4	12
	Artocarpus integer Merrill	1			7	8
	Artocarpus kemando Miq.	1	7			8
	Artocarpus lanceifolia Roxb.	29	6	36	45	116
	Artocarpus nitida Trec.	4		1	1	6

	Artocarpus nitida Trec. ssp. borneense				3	3
	Artocarpus nitida Trec. ssp. griffithii				2	2
	Artocarpus odoratissima Blanco		3		2	5
	Artocarpus sp.	3		1	3	7
	Artocarpus sp.1			2		2
	Artocarpus sp.2			1		1
	Artocarpus tamaran Becc.	1		4	1	6
	Ficus aurata Miq.				1	1
	Ficus grossularioides Burm. f.			2		2
	Ficus obscura Blume			6	3	9
	Ficus sp.	2		2	1	5
	Ficus sp.1			1	2	3
	Ficus uncinulata Corner		1			1
	Ficus vasculosa Wall.	1				1
	Parartocarpus bracteatus Becc.				2	2
	Parartocarpus venenosa Becc.	2	6			8
	Prainea limpato (Miq.) Beumee ex Heyne	1		5	1	7
	Streblus macrophyllus Blume				1	1
	Streblus sp. 1				8	8
	Streblus sp. 2				2	2
Myristicaceae	*Gymnacranthera contractaWarb.*	5	2			7
	Gymnacranthera eugeniifolia (A. DC.) J. Sincl. var. griffithii	8				8
	Gymnacranthera farquhariana Warb.			7	13	20
	Gymnacranthera forbesii Warb.				3	3
	Gymnacranthera ocellata R. T. A.Schouten			2		2
	Gymnacranthera sp.			1		1
	Horsfieldia crassifolia Warb.		6	2	5	13
	Horsfieldia glabra Warb.		3			3
	Horsfieldia grandis Warb.	4	1	3	1	9
	Horsfieldia sp.	1	2	1	1	5
	Horsfieldia sp. 1		1			1
	Horsfieldia subglobosa Warb.		1			1
	Horsfieldia wallichii Warb.	2		4	2	8
	Knema cf. latericia				1	1
	Knema cinerea (Poir) Warb. var. cordata	9				9

	Knema cinerea (Poir) Warb. var. sumatrana	4				4
	Knema cinerea (Poir.) Warb.	40	38			78
	Knema conferta Warb.		1			1
	Knema elliptica Warb.		1			1
	Knema elmeri Merrill			8	7	15
	Knema furfuracea Warb.	14	5			19
	Knema galeata J. Sincl.		1		3	4
	Knema glauca Warb.		6	2	4	12
	Knema hirtela W. J. J. O. de Wilde				3	3
	Knema korthalsii Warb.	1		7		8
	Knema kurtisii Warb. var. arenosa				4	4
	Knema latericia Elmer	10	8	7	19	44
	Knema latifolia Warb.	5				5
	Knema laurina Warb.	7	10		7	24
	Knema lunduensis (Sinclair) W. J. J. O. de Wilde				1	1
	Knema membranifolia H. Winkler	1				1
	Knema palens W. J. J. O. de Wilde			11	10	21
	Knema percoriacea J. Sincl.			3	5	8
	Knema pulchra Warb.			7	10	17
	Knema sp.	1	13	2	7	23
	Knema sp.1		4	4		8
	Knema woodii J. Sincl.				10	10
	Myristica beccarii Warb.	2	14			16
	Myristica crassa King	3				3
	Myristica crassifolia Hook. f. & Thoms.		1			1
	Myristica depressa W. J. J. O. de Wilde			1		1
	Myristica iners Blume	26	17	11	9	63
	Myristica maxima Warb.	5		7	2	14
	Myristica sp.	1	9	1		11
	Myristica sp.1		1			1
	Myristica villosa Warb.	8	4	2		14
	Myristica wallichii Hook. f. et Thoms.	1				1
Myrsinaceae	*Ardisia fulginosa Blume*	2				2
	Ardisia gambleana Furtado		11			11
	Ardisia macrophylla Wall.		1			1

	Ardisia teysmanianna Scheff.		1			1
Myrtaceae	*Eugenia heteroclada Merrill*			1	3	4
	Rhodamnia cinerea Jack.		1			1
	Syzygium acutangulum Niedenzu	2				2
	Syzygium bankense (Hassk.) Merrill & Perry		4			4
	Syzygium baramense (Merrill) Merrill & Perry			3		3
	Syzygium caudatilimbum (Merrill) Merrill & Perry	8			2	10
	Syzygium chloranthum (Duthie) Merrill & Perry	4	13			17
	Syzygium confertum (Korth.) Merrill & Perry	7	5			12
	Syzygium exacavatum Wall.		1			1
	Syzygium fastigiatum (Blume) Merrill & Perry	1				1
	Syzygium grande Wall..	2	3			5
	Syzygium incarnata (Elmer) Merill & Perry		5			5
	Syzygium leptostemon (Korth.) Merrill & Perry	1				1
	Syzygium napiforme (Koord. & Valeton) Merrill & Perry			1		1
	Syzygium nigricans (King) Merrill & Perry				6	6
	Syzygium ochneocarpum (Merrill) Merrill & Perry	15	8		2	25
	Syzygium perpuncticulatum (Merrill) Merrill & Perry	1	8			9
	Syzygium picnanthum Merrill & Perry	7				7
	Syzygium prasiniflorum (Ridley) Merrill & Perry		2			2
	Syzygium sp.	9	36	6	7	58
	Syzygium sp.1	3	10	17	1	31
	Syzygium sp.10				1	1
	Syzygium sp.2		5	1	1	7
	Syzygium sp.3			3	1	4
	Syzygium sp.4			1	6	7
	Syzygium sp.5			2	2	4
	Syzygium sp.6			2		2
	Syzygium sp.7			2		2
	Syzygium sp.8			1		1
	Syzygium sp.9			1		1
	Syzygium stictophyllum Merrill & Perry	24	2			26
	Syzygium subcrenatum Merrill & Perry		1			1
	Syzygium tawahense (Korth.) Merrill & Perry	2		1	5	8
	Syzygium zeylanicum DC.	7				7

	Tristaniopsis whiteana (Griff.) P. G. Wilson & J. T. Waterhouse		1			1
Ochnaceae	*Gomphia serrata (Gaertn.) Kanis*	3	2	1	1	7
Olacaceae	*Ochanostachys amentacea Mast.*	8	2	9	1	20
	Scorodocarpus borneensis Becc.	2				2
	Strombosia ceylanica Gardn.	1			2	3
	Strombosia sp.			1		1
Oleaceae	*cf. Chionanthus sp.*			1		1
	Chionanthus curvicarpus R.Kiew			1		1
	Chionanthus cuspidatua Blume	1	1			2
	Chionanthus nitens Koord. & Valet.		2			2
	Chionanthus olingathus (Merrill) R. Kiew	2	8	3	4	17
	Chionanthus pubicalyx (Ridl.) R. Kiew	2	5			7
	Chionanthus sp.	2		6	4	12
	Chionanthus sp. 1		1			1
Oxalidaceae	*Sarcotheca diversifolia H. Hallier f.*	10	7	2	3	22
	Sarcotheca sp.				1	1
Podocarpaceae	*Podocarpus blumei Endl.*		1			1
	Podocarpus neriifolia D. Don		1			1
Polygalaceae	*Xanthophyllum affine Korth. ex. Miq.*	10		2	3	15
	Xanthophyllum amoenum Chod.				1	1
	Xanthophyllum cf. flavescens Roxb.	9				9
	Xanthophyllum cf. stapfii Chod.	1				1
	Xanthophyllum curtisii King	1				1
	Xanthophyllum ellipticum Korth. ex Miq.		1			1
	Xanthophyllum griffithii Hook. f. ex A. W. Benn.				2	2
	Xanthophyllum macrophyllum Baker				2	2
	Xanthophyllum obscurum A.W. Benn.	1		1	5	7
	Xanthophyllum parvum Chod.	26	14			40
	Xanthophyllum rufum A.W. Benn.	2	1	3	3	9
	Xanthophyllum scortechinii King	1				1
	Xanthophyllum sp.	4	6	1	1	12
	Xanthophyllum sp. 1		4	9	1	14
	Xanthophyllum sp. 2				3	3
	Xanthophyllum sp. 3				1	1
	Xanthophyllum stipitatum A.W.Benn.				2	2

Proteaceae	*Helicia fuscotomentosa Suesseng*		1			1
	Helicia petiolaris Benn.	7	2			9
	Helicia sp.				2	2
Rhamnaceae	*Ziziphus angustifolius(Miq.) Hatusima ex van Steenis*	2	2			4
	Ziziphus sp.			1		1
Rhizoporaceae	*Anisophyllea corneri Ding Hou*	2				2
	Carallia brachiata Merrill	3	2	2	2	9
	Gynotroches axilaris Blume	1		2		3
	Gynotroches sp.			1		1
Rosaceae	*Prunus arborea (Blume) Kalkm.*	2	2			4
	Prunus beccarii (Ridley.) Kalkm.				1	1
	Prunus sp.	1			4	5
	Prunus sp.1			1	1	2
	Prunus sp.2			1	3	4
	Rosaceae		1			1
Rubiaceae	*Adina polycephala Benth.*	3				3
	Anthocephalus cadamba Miq.		6	11	3	20
	cf. Pleiocarpidia sp.				1	1
	Gardenia sp.			2		2
	Gardenia tubifera Wall.	3		1	3	7
	Ixora brachyantha Merrill	4	8			12
	Ixora fluminalis Ridley			10	3	13
	Jackiopsis ornata (Wall.) C. E. Risdale		6			6
	Lasianthus sp.			1		1
	Maclurodendron porteri (Hook. f.) T. G. Hartley		1			1
	Nauclea sp.	2		3	2	7
	Neonauclea sp.				2	2
	Pleiocarpidia polyneura (Miq.) Bremek	2				2
	Pleiocarpidia sp.			1		1
	Porterandia anisophylla (Jack ex Roxb.) Ridley	2		3		5
	Rubiaceae		2	2		4
	Tarenna cumingiana Elmer				1	1
	Timonius borneensis Valet.		5			5
	Timonius lasianthoidesValet.			5		5
	Timonius sp.	1	1			2

	Timonius sp. 1	3				3
	Tricalysia malaccensis Merrill	3	5			8
	Urophyllum corymbosum Korth.		2			2
Rutaceae	*Tetractomia sp.*	3				3
	Tetractomia sp. 1		1			1
Sabiaceae	*Meliosma nitida Bl.*		1			1
	Meliosma sp.			2		2
Santalaceae	*Scleropyrum wallichianum A. Arn.*	3				3
Sapindaceae	*Dimocarpus dentatus W. Meijer ex Leenhouts*	6	1	1	13	21
	Lepisanthes alata (Blume) Leenh.	1				1
	Nephelium cuspidatum Blume	2	2	3		7
	Nephelium juglandifolium Blume	1				1
	Nephelium maingayi Hiern	2				2
	Nephelium mutabile Blume		7			7
	Nephelium ramboutan-ake (Labill.) P.W. Leenhouts	1			1	2
	Nephelium sp.	1		1	1	3
	Nephelium uncinatum Radlk.	13		1	12	26
	Paranephelium nitidum King			1	5	6
	Pometia alnifolia Radlk.	1				1
	Pometia pinnata G.Forst.	1	5	7		13
	Xerospermum laevigatum Radlk.		1			1
	Xerospermum noronhianum Blume	1			2	3
Sapotaceae	*Chrysophyllum roxburghii G. Don*			1		1
	Chrysophyllum sp.				1	1
	Madhuca borneensis van. Royen			1	10	11
	Madhuca cf. prolixa (Pierre ex Dubard) P.C.Yii & P. Chai	14				14
	Madhuca erythrophylla H. J. Lam		1			1
	Madhuca magnifica S. Moore		24			24
	Madhuca malaccensis H. J. Lam		3			3
	Madhuca mindanaensis Merrill			4	11	15
	Madhuca sericea H. J. Lam				6	6
	Madhuca sp.	3	1		14	18
	Madhuca sp.1		1			1
	Palaquium beccarianum (Pierre) van Royen				4	4
	Palaquium calophyllum Pierre ex Burck	3		3		6

	Palaquium cochleariifolium van Royen		1			1
	Palaquium dasyphyllum Pierre ex Dubard.	6	4			10
	Palaquium ferox H. J. Lam		5			5
	Palaquium gutta Burck	2	1			3
	Palaquium quercifolium Burck	15	7	1		23
	Palaquium rostratum Burck	10	10	1	9	30
	Palaquium sericeum H. J. Lam			15	1	16
	Palaquium sp.	2	1		3	6
	Palaquium sp.1		4			4
	Palaquium stenophyllum H. J. Lam	1		24	27	52
	Palaquium sumatranum Burck		1			1
	Payena lerii Kurz	2				2
	Payena lucida A. DC.			2		2
	Payena sp.		1	2		3
	Pouteria malaccensis (C. B. Clarke) Baehni	1	2			3
Simaroubaceae	*Allantospermum borneense Forman*				2	2
	Irvingia malayana Oliver		4	2	2	8
Sonneratiaceae	*Duabanga moluccana Blume*		1	1		2
Staphyliaceae	*Turpinia sphaerocarpa Hassk.*			1		1
Sterculiaceae	*Heritiera elata Ridley*	6	2	1	1	10
	Heritiera javanica (Blume) Kosterm.	1				1
	Heritiera simplicifolia (Mast.) Kosterm.		1		8	9
	Heritiera sp.				1	1
	Heritiera sumatrana (Miq.) Kosterm.	6	5	3		14
	Pterospermum javanicum Jungh.		1		4	5
	Scaphium borneense (Merrill) Kostermans				3	3
	Scaphium macropodum Beume ex K. Heyne	21	11	9	12	53
	Sterculia coccinea Jack		2			2
	Sterculia foeltida Linn.				12	12
	Sterculia macrophyllla Vent.				2	2
	Sterculia oblongata R. Br.	3				3
	Sterculia rubiginosa Vent.		1	2		3
	Sterculia sp.		2	1	5	8
	Sterculia sp.1		1	13	2	16
Styracaceae	*Bruinsmia styracoides Boerlage & Koorders*			1		1

Symplocaceae	*Symplocos cerasifolia Wall.*			5		5
	Symplocos cochinchinensis S. Moore	2				2
	Symplocos crassipes C. B.Clarke	1	1			2
	Symplocos fasciculata Roxb. ex A. DC.			1	1	2
	Symplocos rubiginosa Wall ex A. DC.	1				1
	Symplocos sp.	1	1		1	3
	Symplocos sp. 1		3			3
Theaceae	*Adinandra borneensis Kobuski*	1	12			13
	Adinandra subsessilis Airy Shaw			5	6	11
	Ternstroemia aneura Miq.		7			7
	Ternstroemia sp. 1		2			2
	Tetramerista glabra Miq.		14			14
Thymelaeaceae	*Aquilaria beccariana van Tiegh.*		1	2		3
	Aquilaria malaccensis Lam.	1	1	1	3	6
	Gonystylus affinis Radlk.			1	6	7
	Gonystylus forbesii Gilg.	1				1
	Gonystylus keithii Airy Shaw	1				1
	Gonystylus sp	1			2	3
	Gonystylus sp 1				1	1
Tiliaceae	*Brownlowia peltata Benth.*		1	2	5	8
	cf. Microcos sp.				1	1
	Grewia fibrocarpa Mast.			1	1	2
	Grewia sp.		1			1
	Grewia tomentosa Juss.		1			1
	Microcos cinnamomifolia (Burret) Stapf ex P.S.Ashton	3	2		1	6
	Microcos crassifolia Burret			1		1
	Microcos paniculata Burret	1				1
	Microcos tomentosa Sm.	3		3	1	7
	Pentace borneensis Pierre	15	4			19
	Pentace erectinervia Kosterm.			1		1
	Pentace laxiflora Merrill	4		7		11
	Pentace sp.				3	3
	Pentace sp. 1				14	14
	Pentace sp. 2				13	13
	Pentace sp. 3				1	1

	Pentace sp. 4				1	1
	Pentace triptera Mast.		1	1	5	7
Ulmaceae	*Gironniera nervosa Planch.*	6	4	8	16	34
	Gironniera subaequalis Planch.	2	6			8
Urticaceae	*Laportea oblanceolata Merrill*			5	4	9
Verbenaceae	*Geunsia pentandra Merrill*			12	2	14
	Teijsmanniodendron coriaceum (C.B. Clarke) Kosterm	6				6
	Teijsmanniodendron scaberrimum Kosterm.	6				6
	Teijsmanniodendron simplicifolium Merrill.	1	29			30
	Teijsmanniodendron simplicioides Kosterm.	13	1	1	1	16
	Teijsmanniodendron sp.				6	6
	Teijsmanniodendron sp.1			7	19	26
#N/A	*Unident 1*				5	5
	Unident 4		12		1	13
	Unident.2	2				2
	Unident.3	6				6
	Unident.5	1				1
Number of trees/4 Ha		#REF!	#REF!	#REF!	#REF!	#REF!
Number of species/4 Ha		0	0	0	0	0
#N/A	Dead trees	110	132	104	152	498

Appendix 2. Tree species composition in 1-ha plot of primary and logged lowland forests in the Bulungan Research Forest-CIFOR, East Kalimantan.

Family	**Species Name**	**PF**				**LF-5**				**LF-10**				**LF-30**				**Total**
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Alangiaceae	*Alangium javanicum (Blume) Wangerin*	5		5	1				1	1		4	1			2	4	24
	Alangium longiflorum Merrill												1					1
	Alangium ridleyi King													1		2		3
Anacardiaceae	*Buchanania arborescens F. Muell.*		1					1					1					3
	Buchanania sessifolia Blume					4	2		4			4						14
	Campnosperma auriculata Hook. f.									3						1		4
	Dracontomelon dao Merrill & Rolfe									1				1	3			5
	Drimycarpus luridus (Hook.f.) Ding Hou				1				2		2							5
	Drimycarpus sp.													1				1
	Gluta macrocarpa (Engl.) Ding Hou											1		2	1	1	1	6
	Gluta wallichii (Hook. f.) Ding Hou	11	2	9	18	4	5	12	6	2	4	4	3		3	1		84
	Koordersiodendron pinnatum Merrill		1	1					2					2	3	2		11
	Mangifera foetida Lour.															1	1	2
	Mangifera macrocarpa Blume													1				1
	Mangifera magnifica K. M. Kochummen							1										1
	Mangifera pajang Kosterm.													1				1
	Mangifera sp. 1							1										1
	Mangifera sp. 2			1														1
	Mangifera swintoniodes Kosterm	18	15	26	17	7			15			1						99
	Mangifera torquenda A. J. G. H. Kosterm	1		1	6													8

	Melanochyla auriculata Hook. f.										1							1
	Melanochyla beccariana Oliver		1						1									2
	Melanochyla bullata Ding Hou					2												2
	Melanochyla caesia (BL.) Ding Hou					1			2									3
	Melanochyla elmeri Merrill			3	3													6
	Melanochyla fulvinervia (Blume) Ding Hou															1		1
	Melanochyla sp.										1			1	2	2	2	8
	Melanochyla sp.1					1	1						1					3
	Melanochyla sp.2												3					3
	Melanochyla sp.3														1			1
	Melanochyla sp.4															1	5	6
	Parishia insignis Hook.f.															1		1
	Semecarpus burburyanus Gibbs															1		1
	Semecarpus sp.													2				2
	Swintonia glauca Engl.						8	8										16
Annonaceae	*Anaxagorea ramiflora Boerl.*								2									2
	cf. Mitrephora sp.														1	1		2
	cf. Orophea sp.														2			2
	cf. Phaeanthus sp.														10			10
	Cyathocalyx bancanus Boerl.					1	3											4
	Cyathocalyx carinatus (Ridley) J.Sincl.									1		1						2
	Cyathocalyx magnifica Diels			1														1
	Cyathocalyx sp.				1													1
	Cyathocalyx sumatrana Scheff.									1			3		2	1	1	8
	Enicosanthum paradoxum Becc.									1						1		2
	Enicosanthum sp.												1					1
	Goniothalamus sp.									1								1
	Mezzettia parviflora Becc.			2	1		1	1	3		1			2	1	1		13
	Mitrephora maingayi Hook. f. & Thoms.					2												2
	Monocarpia kalimantanensis P. J. A. Kessler													4		1		5
	Polyalthia cauliflora Hook.f. & Thoms.	3		9	5					1			1		2	3	2	26
	Polyalthia glauca Boerl.												1					1
	Polyalthia lateriflora King			3			6				2				1			12
	Polyalthia microtus Miq.													2				2
	Polyalthia rumphii Merrill			2	1					2	3	2	4	2		1		17

	Polyalthia sp.	1			2	1	2		1			1		2	1			11
	Polyalthia sp.1				2					4								6
	Polyalthia sp.2									1								1
	Polyalthia sp.3									2								2
	Polyalthia sp.4											1						1
	Polyalthia sp.5												1					1
	Polyalthia sp.6																2	2
	Polyalthia subcordata Blume								1									1
	Polyalthia sumatrana (Miq.) Kurz	3	3	1	8	2	6	1			6	5	4	1	1			41
	Popowia hirta Miq.					1		1										2
	Pseuduvaria cf. rugosa Merrill		2															2
	Pseuduvaria reticulata Miq.				1													1
	Sageraea elliptica Hook. f. & Thoms.							1										1
	Sageraea lanceolata Miq.		1					3						2	1	2	5	14
	Xylopia caudata Hook. f. & Thoms.					2	3	6	1									12
	Xylopia elliptica Maing. ex Hook. f.									1	1					1	1	4
	Xylopia ferruginea Baill.					2				1								3
	Xylopia malayana Hook.f. & Thoms.	1									1	1		4		1	4	12
	Xylopia sp.	1					2				1							4
Apocynaceae	*Alstonia iwahigensis Elmer*										1							1
	Alstonia sp.															2	1	3
	Alstonia spathulata Blume								1									1
	Apocynaceae							1										1
	Dyera costulata Hook. f.				1	2		1						2		1	3	10
	Kibatalia arborea G. Don					1												1
	Kibatalia flavida Blume													2				2
	Kibatalia maingayi (Hook. f.) R. E. Woodson							2										2
	Kibatalia villosa Rudjiman										1				1			2
	Tabernaemontana macrocarpa Korth. ex Blume										1							1
Aquifoliaceae	*Ilex cymosa Blume*													1			1	2
	Ilex sp. 1					1												1
	Ilex sp. 2		2															2
Bombacaceae	*Coelostegia chartacea Soeg. Reksod.*									2			1		1			4
	Coelostegia sp.										2	1						3
	Coelostegia sp. 1															3		3

	Durio acutifolius (Mast.) Kosterm.	3												2				5
	Durio dulcis Becc.									2		1					1	4
	Durio grandiflorus (Mast.) Kosterm. & Soeg.	1		1	2		2	1										7
	Durio graveolens Becc.					1			1				2					4
	Durio griffithii Bakh.	2		1									1			1	1	6
	Durio kutejensis Becc.											3				1		4
	Durio lanceolatus Mast.	2		3	1	2	1	3								1	1	14
	Durio oxleyanus Griff.	1								1								2
	Durio sp. 1						1											1
	Durio sp.2						7					1						8
	Durio testudinarius Becc.	1		1														2
	Neesia synandra Mast.	1			2		1		1	1	1			2	2			11
Burseraceae	*Canarium denticulatum Blume*												1					1
	Canarium hirsutum Willd.													8				8
	Canarium littorale Blume	4	2			2	2	6	4			1			1			22
	Canarium megalanthum Merrill													1				1
	Canarium odontophyllum Miq.		3		1								2		4	1		11
	Canarium pillosum A. W. Benn.	3	1	3				3	3									13
	Canarium sp.		1	2			2									1		6
	Canarium sp. 2														3			3
	Canarium sp.1									1	2	1						4
	Dacryodes costata (A. W. Benn.) H. J. Lam	2				5				3				1				11
	Dacryodes crassipes Kalkman						1	1										2
	Dacryodes incurvata (Engl.) H. J. Lam	4		10	21	3		4	4	1			1		6	2	4	60
	Dacryodes laxa (A. W. Benn.) H. J. Lam					1		1						1			1	4
	Dacryodes rostrata (Blume) H. J. Lam forma pubescens	3	9	2	1	4	6	7	10	1	7	4	2	4	4	4	5	73
	Dacryodes rubiginosa (A. W. Benn.) H. J. Lam								1									1
	Dacryodes rugosa (Blume) H.J. Lam	8	6	4	3	8	2	1	2	2	4	9	3	5	1	5	4	67
	Dacryodes sp.	1										1						2
	Santiria apiculata A.W.Benn.									1	1			2	1			5
	Santiria griffithii Engl.					1	2	1						1				5
	Santiria laevigata Blume	1											3					4
	Santiria oblongifolia Blume	1			1									1		2		5
	Santiria rubiginosa Blume							1	1									2

	Santiria sp.	1												1		1		3
	Santiria sp.1	1					3											4
	Santiria tomentosa Blume	1		1	3			1				1		2		1		10
	Triomma malaccensis Hook. f.																2	2
Caesalpiniaceae	*Crudia teniupes Merrill*											1						1
Caprifoliaceae	*Viburnum sp.*											1	1				1	3
Celastraceae	*Bhesa paniculata Arn.*			1			2	1	1			2						7
	Celastraceae												1					1
	Kokoona littoralis M. A. Laws.							1										1
	Kokoona reflexta (M. A. Lawson) Ding Hou				2											1	1	4
	Lophopetalum beccarianum Pierre	3			1													4
	Lophopetalum cf. glabrum Ding Hou															3	3	6
	Lophopetalum javanicum Turcz.																5	5
	Lophopetalum sp.													8		2		10
	Lophopetalum subobovatum King					4		4	1									9
Chrysobalanaceae	*Atuna excelsa (Jack) Kosterm.*			3	1	3	4	1										12
	Atuna racemosa Rafin.					1					1							2
	Atuna sp.														1			1
	Licania splendens (Korthals) Prance					1		1										2
	Parinari racemosum Merrill					1												1
Combretaceae	*Terminalia foetidissima Griff.*												1					1
	Terminalia sp. 1					1												1
	Terminalia subspathulata King											1						1
Cornaceae	*Ellipanthus tomentosus Kurz*										2					2	6	10
	Mastixia bracteata C. B. Clarke			1														1
	Mastixia rostrata Blume						1											1
	Mastixia sp.										1	2					1	4
	Mastixia trichotoma Blume			1			1		2									4
Crypteromiaceae	*Crypteronia macrophylla van Beusekom-Osinga*												1					1
Dilleniaceae	*Dillenia excelsa Martelli*		7	2	1			1	16	1	4		1	1	2	7		43
	Dillenia eximia Miq.							2										2
	Dillenia grandifolia Wall.					1												1
	Dillenia pentagyna Roxb.					1		3										4
	Dillenia reticulata King														1			1
Dipterocarpaceae	*Anisoptera costata Korth.*			1	1	1				1								4

cf. Hopea sp.											4			3	1		8
Dipterocarpus cornutus Dyer														1			1
Dipterocarpus crinitus Dyer			3										11			1	15
Dipterocarpus elongatus Korth.	1	2						1									4
Dipterocarpus eurynchus Miq.	8	4	3	11								1		1	9	1	38
Dipterocarpus gracilis Blume	1	10															11
Dipterocarpus humeratus van Slooten												15		2			17
Dipterocarpus lowii Hook. f.					4	1	9										14
Dipterocarpus pachyphyllus Meyer		2											4		3	8	17
Dipterocarpus sp.	2											2		2	2		8
Dipterocarpus sp. 2																4	4
Dipterocarpus sp.1												20				1	21
Dipterocarpus stellatus Vesque	5				17		10	2			1						35
Dipterocarpus tempehes van Slooten												1					1
Dipterocarpus verrucosus Foxworthy ex. v. Slooten			1									1					2
Dryobalanops lanceolata Burck		21	1	1					3	4	9	5	1	2			47
Hopea cernua Teijsm. & Binn.												2					2
Hopea cf. obovoidea Sloot.		1															1
Hopea dryobalanoides Miq.								1	1				23	12	22	34	93
Hopea ferruginea Parijs	11	34	27		6	31	5	16									130
Hopea mengerawan Miq.				8													8
Hopea semicuneata Symington															1	9	10
Hopea sp.		1						1									2
Hopea sp. 1														2			2
Parashorea lucida Kurz															4		4
Parashorea malaanonan Merrill	3	15	5	5		9		18	14	2		4		29	7		111
Parashorea parvifolia Wyatt-Smith ex P. S. Ashton	1	2	1	11				1									16
Parashorea sp. 1					1												1
Parashorea tomentella (Symington) Meijer										3		2					5
Shorea agamii P. S. Ashton	7	1	7	2	1	1				1			8	1	3	4	36
Shorea angustifolia P. S. Ashton	2			45									31	3	16	5	102
Shorea atrinervosa Symington				6			3		3		2			2	1		17
Shorea beccarii Dyer ex Brandis	2		8	2			2							5	41	23	83
Shorea brunnescens P. S. Ashton							12										12
Shorea cf. almon Foxworthy									1								1

Shorea cf. atrinervosa Symington								1				8					9
Shorea cf. maxwelliana King				6				1									7
Shorea cf. obovoidea van Slooten		25	10	1													36
Shorea cf. ovalis Blume								1				1					2
Shorea elliptica Meijer				2	1	1	2										6
Shorea faguetiana Heim	1	5	2	2													10
Shorea fallax Meijer						4		7									11
Shorea hopeifolia (Heim) Symington	3	4		2				3		2	1	3		1	1		20
Shorea inappendiculata Burck	1								1		2	2					6
Shorea johorensis Foxworthy	1		10	3		1	1	3	2	8	4		14	3	5	2	57
Shorea laevifolia(Parijs) Endert						1											1
Shorea lamellata Foxworthy														3			3
Shorea leprosula Miq.	3	1	1		1	1		1	1					11	7	1	28
Shorea macrophylla (de Vriese) P. S. Ashton		1															1
Shorea macroptera Dyer	5	6	17	18	10		6					1				14	77
Shorea malaononan Blume								2									2
Shorea maxwelliana King		4		2			5	1									12
Shorea multiflora (Burck) Symington											1	4			8	1	14
Shorea ochracea Symington					1		2										3
Shorea ovalis Blume	3	1	1	7	3			6			6	3		3	12	1	46
Shorea parvifolia Dyer	15	12	19	26	7	13	10	49	16	26	32	4	7	4	5	20	265
Shorea parvistipulata Heim	4		4	3					4		1	3		4	1	2	26
Shorea patoienis P. S. Ashton															2		2
Shorea pauciflora King	6	3	2	10	1		5	3	2							3	35
Shorea pinanga Scheff.	2	23	2	15			1	2	10			5	25	1	2		88
Shorea seminis v. Slooten		3															3
Shorea smithiana Symington													2				2
Shorea sp.	3	6	3	3	2	3	5						5				30
Shorea sp. 4													2				2
Shorea sp. 5													7				7
Shorea sp. 6								1									1
Shorea sp.1							1	3	1	5							10
Shorea sp.2													7		6	7	20
Shorea sp.3					5		1										6
Shorea venulosa G. H. S. Wood ex Meijer							4										4

	Shorea xanthophylla Symington		29	1	7	1												38
	Vatica albiramis v. Slooten	3	7			3		5										18
	Vatica granulata v. Slooten	8	17	18					1								1	45
	Vatica micrantha v. Slooten																30	30
	Vatica nitens King																1	1
	Vatica oblongifolia Hook.f.	1	1	3	4	1	1		5		1							17
	Vatica pauciflora Blume						1											1
	Vatica rassak Blume		1						2									3
	Vatica sarawakensis Heim												2	2	1			5
	Vatica sp.		3					1									2	6
	Vatica sp. 1								1		1		10			18	19	49
	Vatica umbonata Burck	9	1	10	11					2	2			4		6	6	51
	Vatica vinosa P.S. Ashton	5		1	21				3									30
Ebenaceae	*Diospyros cf. oblonga Wall.*		1						1									2
	Diospyros borneensis Hiern		2		1						1			2	2	3	3	14
	Diospyros buxifolia Hiern	25													2	2		29
	Diospyros cf. korthalsiana Hiern														1			1
	Diospyros cf. pendula Hasselt ex Hassk.																8	8
	Diospyros cf. perfida Bakh.		2															2
	Diospyros cf. sumatrana Miq.		4															4
	Diospyros curraniopsis Bakh.		2	1			1		2									6
	Diospyros diepenhorstii Miq.					2												2
	Diospyros elliptifolia Merrill		1															1
	Diospyros evena Bakh.							5										5
	Diospyros foxworthyii Bakh.	4	6	7	2													19
	Diospyros frutescens Blume		3	1					2	2		1	6		2	1	5	23
	Diospyros hallierii Bakh.		1															1
	Diospyros lanceaefolia Roxb.	1	1															2
	Diospyros levigata								2									2
	Diospyros macrophylla Blume									2								2
	Diospyros malayana Bakh.						2						1		2			5
	Diospyros oblonga Wall.		7	2	3	3	4		4									23
	Diospyros pendula Hasselt ex Hassk.													10				10
	Diospyros pilosanthera Blanco									2		1						3
	Diospyros polyalthioides Hiern														1			1

	Diospyros sp.	2	3		1	4	8		6	2	4	6	1	3	7		2	49
	Diospyros sp.1						2	1	11		3	2	5					24
	Diospyros sp.2															1		1
	Diospyros sp.3											1	1					2
	Diospyros sp.4												1				1	2
	Diospyros sp.5												1		3			4
	Diospyros sp.7														1			1
	Diospyros sp.8									2	1	1						4
	Diospyros sumatrana Miq.		19	6	4				7	3	4		3	3		4		53
	Diospyros toposoides King ex Gamble				1				1									2
	Diospyros wallichii King ex Gamble		1															1
Elaeocarpaceae	*Elaeocarpus cupreus Merrill*										1							1
	Elaeocarpus parvifolius Wall.	1																1
	Elaeocarpus pedunculatus Wall.							1										1
	Elaeocarpus sp.										1	1					1	3
	Elaeocarpus sp.1											1						1
	Elaeocarpus sp.2											1						1
	Sloanea javanica (Miq.) Koord. & Valeton		1							1			2	2				6
Euphorbiaceae	*Antidesma leucopodum Miq.*									1			1			3		5
	Antidesma neurocarpum Miq.													2				2
	Antidesma sp.											1	1					2
	Antidesma sp. 1								1									1
	Antidesma trunciflorum Merrill		4	3	1													8
	Aporosa benthamiana Hook. f.							1					1					2
	Aporosa confusa Gage														3	1		4
	Aporosa falcifera Hook. f.	1		4	2		2			1	3		2		1		2	18
	Aporosa grandistipula Merrill		1										3	1				5
	Aporosa lucida (Miq.) Airy Shaw	1			1													2
	Aporosa lunatum Kurz					1												1
	Aporosa nitida Merrill		2	2	1					1	1	1			1	2		11
	Aporosa prainianaKing ex Gage						1	1										2
	Aporosa sp.				1		4	1						1				7
	Aporosa subcaudata Merrill	1	1	4	1	2	1	1	2	1	1	2			1			18
	Baccaurea angulata Merrill						1		3									4
	Baccaurea bracteata Muell. Arg.	1																1

Baccaurea edulis Merrill	3	1	1	2	1	5	2	5									20
Baccaurea javanica Muell. Arg.	5		1	2				1									9
Baccaurea kunstleri King ex Gage			2			2	1										5
Baccaurea macrocarpa Muell. Arg.	1	2	1	1		1			1			1	4				12
Baccaurea minor Hook. f.	4		7	2		1	2										16
Baccaurea odoratissima Elmer									1	1							2
Baccaurea pubera Muell. Arg.	1		1	1			1										4
Baccaurea pyriformis Gage										1	3	3			3	2	12
Baccaurea sp.	1		1			22	1	1				1	2				29
Baccaurea sp.1						2				3	1						6
Baccaurea stipulata J. J. Smith	3	3	1					1									8
Baccaurea sumatrana Muell. Arg.					6	1	13	2									22
Baccaurea tetandra Muell. Arg.										1	1	2					4
Baccaurea trunciflora Merrill									1								1
Blumeodendron calophyllum AiryShaw									1				2	1	1		5
Blumeodendron cf. tokbrai Kurz	1		2	1				5	1							1	11
Blumeodendron elateriospermum J. J. Smith	2																2
Bridelia glauca Blume										1							1
Castanocarpus sp.										1							1
Cephalomappa beccariana Baill.	11		2	1					2								16
Cephalomappa lepidotula Airy Shaw					5	2											7
Cephalomappa malloticarpa J. J. Smith					1									4	2	2	9
Chaethocarpus castanocarpus Thw.	2				7	3	3			1	1			1		1	19
Cleistanthus bakonensis Airy Shaw					8		7										15
Cleistanthus beccarianus Jablonszky									3			3					6
Cleistanthus myrianthus (Hassk.) Kurz		1			1	2		2		1				1			8
Cleistanthus sp.	1												1				2
Cleistanthus sumatranus Muell. Arg.																1	1
Coccoceras borneense J. J. Smith.		21		1													22
Croton argyratus Blume					16												16
Drypetes crassipes Pax & K. Hoffm.		2	1	1			1						4		2	5	16
Drypetes kikir Airy Shaw																14	14
Drypetes laevis Pax et Hoffm.	1			8			4										13
Drypetes longifolia Pax & K. Hoffm.			1							1							2
Drypetes oblongifolia (Bedd.) Airy Shaw		1							1					2	1		5

Drypetes polyneura Airy Shaw	4		1	4									1	2	2	1	15
Drypetes sp.						2							1	1			4
Elateriospermum tapos Blume	1		2			3		1	23	26	13	6	10				85
Glochidion arborescens Blume		1															1
Glochidion bakonensis					1		1										2
Glochidion borneensis Boerl.		1							1								2
Glochidion celastroides Pax							3										3
Glochidion cf. arborescens Blume							1										1
Glochidion obscurum Blume														1		5	6
Glochidion rubrum Blume											1			1	3		5
Glochidion sericeum Zoll. & Mor.												2					2
Glochidion sp.													3				3
Koilodepas brevipes Merr.								4									4
Koilodepas laevigatus Airy Shaw														47			47
Macaranga aetheadenia Airy Shaw		1								1		1					3
Macaranga bancana Muell. Arg.						1			7	15	43	38				1	105
Macaranga beccariana Merrill			1						1	1	4	7			4	1	19
Macaranga cf. hullettii King ex Hook.f.												6					6
Macaranga cf. indistincta T. C. Whitmore											2	5					7
Macaranga conifera (Zoll.) Muell. Arg.													1	1	14	36	52
Macaranga gigantea Muell. Arg.	2	1			2	1		30	5	7	3	1		7	3	7	69
Macaranga grandibracteolata Stuart J.Davies												3					3
Macaranga hosei King ex Hook.f.									1	20	3	4	1	2			31
Macaranga hypoleuca Muell. Arg.									21	35	51	35	6	30	44	4	226
Macaranga lamellata T. C. Whitemore											2						2
Macaranga lowii King ex Hook.f.	14		1	7	6		2			1		9	1		4	7	52
Macaranga motleyana Muell. Arg.					1	1		6								1	9
Macaranga pearsonii Merrill									27	85	65	49		2		1	229
Macaranga pruinosa Muell. Arg.						3		11	1								15
Macaranga repando-dentata Airy Shaw								1						2	9		12
Macaranga sp.								1									1
Macaranga winkleri Pax & K. Hoffm.								1	2	3	1	7					14
Mallotus eucaustus Airy Shaw	68	1			6		2						16				93
Mallotus griffthianus Hook. f.													4				4
Mallotus korthalsii Muell. Arg.		1															1

	Mallotus macrostachyus Muell. Arg.										1							1
	Mallotus moritzianus Muell. Arg.			1	1	3	1		2									8
	Mallotus muticus (Muell. Arg.) Airy Shaw						3					3	6			1		13
	Mallotus peltatus Muell. Arg.	1																1
	Mallotus penangensis Muell. Arg.		8	3	9	11		8	8	10	7	4	4	9	1	7		89
	Mallotus sp.												1	1				2
	Mallotus subcaudatus					1												1
	Mallotus wrayi King ex Hook. f.									5	3	3				11	7	29
	Neoscortechinia kingii Pax & K. Hoffm.			2	1							1						4
	Neoscortechinia philippinensis (Merr.) P. C. Welzen												1					1
	Paracroton pendulus Miq.	4			2	1	1			2	5		5	1	5	3	1	30
	Phyllanthus emblica Linn.	1																1
	Pimelodendron griffithianum (Muell. Arg.) Hook. f.	3		1	8	1	2	1	2	2	3		1	6		4	5	39
	Pimelodendron papaveroides J. J. Smith					1	1											2
	Ptychopxis sp. 1						1	1										2
	Ptychopyxis arborea(Merrill) Airy Shaw		1	1	1	4												7
	Ptychopyxis bacciformis Croizat								3	1		1	2		2	1		10
	Ptychopyxis sp.			1			1			1				10	1	1		15
	Trigonopleura malayana Hook. f.			1				1										2
	Trigonostemon sp.					1	5		1									7
	Trigonostemon sp. 1					1			1									2
Fagaceae	*Castanopsis fulva Gamble*													1			2	3
	Castanopsis megacarpa Gamble										1							1
	Castanopsis motleyana King				1		1	4	1								3	10
	Castanopsis sp.			2	2													4
	Castanopsis sp. 1																1	1
	Castanopsis sp. 2																1	1
	Lithocarpus blumeanus Rehder							1	1									2
	Lithocarpus cantleyanus Rehder			1				6										7
	Lithocarpus conocarpa Rehder		4															4
	Lithocarpus cooperta Rehder															1		1
	Lithocarpus ewyckii Rehder	1		4	8		1		2									16
	Lithocarpus gracilis (Korth.) Soepadmo				1	3	2	4	1	1		1	1					14
	Lithocarpus lucidus Rehder					2												2
	Lithocarpus nieuwenhuisii (Seem) A. Camus					1		1	2									4

	Lithocarpus reflexus (King) A. Camus						1		2									3
	Lithocarpus sp.			2	1		1					2				2	3	11
	Lithocarpus sp.1					2	3			1		1				1		8
	Lithocarpus sp.2						1			2	1							4
	Lithocarpus sp.3										1							1
	Lithocarpus sp.4										3					1		4
	Lithocarpus sp.5											2						2
	Lithocarpus urceolaris (Jack) Merrill	1	2						1									4
	Quercus argentata Korth.	1													1			2
	Quercus gemelliflora Blume	1	1															2
	Quercus sp.				1									1				2
	Quercus sp. 1							1										1
Flacortiaceae	*Flacourtia rukam Zoll. & Mor.*								1									1
	Homalium grandiflorum Benth.								1									1
	Hydnocarpus borneensis Sleumer		2	2														4
	Hydnocarpus castanea Hook. f. et Thoms			1														1
	Hydnocarpus kuenstleri Warb.			6	1													7
	Hydnocarpus polypetalus (v.Slooten) Sleum.			2	5													7
	Hydnocarpus sp.			3	2													5
	Hydnocarpus sp. 3														3			3
	Hydnocarpus sp.1									7	2	7	3		1	1		21
	Hydnocarpus sp.2										1							1
	Hydnocarpus wodii Merrill	3		2	3													8
	Hydnocarpus wrayi King		1															1
	Ryparosa baccaureoides Sleum.		1	3	3													7
	Ryparosa hirsuta J. J. Smith								1									1
	Ryparosa kostermansii Sleum.										1							1
	Ryparosa sp.										1			1				2
Guttiferae	*Calophyllum cf. hosei Ridley*	1	1	3														5
	Calophyllum cf. lowii Planch. & Triana					3	1	12	2									18
	Calophyllum pulcherrimum Wall.			1	1		2	2	1									7
	Calophyllum sp.										1	1		1				3
	Calophyllum sp. 3														1			1
	Calophyllum sp. 4														1	2		3
	Calophyllum sp.1	2										1						3

	Calophyllum sp.2												1					1
	Calophyllum venulosum Zoll.		1									1						2
	Garcinia bancana (Miq.) Miq.						1	2	1									4
	Garcinia celebica L.			1														1
	Garcinia cf. griffithii T. Anders						1		1								1	3
	Garcinia dioica Blume			1														1
	Garcinia gaudichaudii Planch. & Triana	1				1	1	1										4
	Garcinia macrophylla Miq.		1						1									2
	Garcinia nervosa Miq.	3	1			1												5
	Garcinia parvifolia Miq.	1	4	3	2	1			2		3	1						17
	Garcinia penangiana Pierre	1		2														3
	Garcinia rostrata Hort. ex Boerl.			1	1													2
	Garcinia sp.						4	1		1		1		3				10
	Garcinia sp. 5															2	2	4
	Garcinia sp.1								3	1							1	5
	Garcinia sp.2								2		1	1				2	1	7
	Garcinia sp.3					1		1				1			1	1		5
	Garcinia sp.4												3					3
	Kayea borneensis P. F. Stevens		1															1
	Mesua borneensis P.F. Stevens		1			2	3		7									13
	Mesua cf. conooidea											1						1
	Mesua sp.											2						2
	Mesua sp.1																1	1
Hypericaceae	*Cratoxylum arborescens Blume*							1										1
	Cratoxylum formosum Benth. & Hook. f. ex Dyer									1								1
	Cratoxylum sumatranum Blume		1											1				2
Icacinaceae	*Stemonurus grandifolius Becc.*					1							1					2
	Stemonurus macrophyllus Blume							1	1									2
	Stemonurus scorpioides Becc.														1	1	1	3
	Stemonurus scundiflorus Blume	1	1	2			1	1	1									7
	Stemonurus sp.										2			3	2	2	1	10
	Stemonurus umbellatus Becc.															1		1
Lauraceae	*Actinodaphne glabra Blume*					1		1		1								3
	Alseodaphne elliptica								2									2
	Alseodaphne elmeri Merrill												1	4				5

Alseodaphne glabra Blume													3				3
Alseodaphne glomerata Nees							1										1
Alseodaphne peduncularis Hook. f.									1					1	1		3
Alseodaphne sp.									1	1		2	1		2	1	8
Alseodaphne sp. 1						1	3			2				2	4	3	15
Alseodaphne sp.2										1							1
Alseodaphne sp.3										2							2
Alseodaphne umbelliflora Hook. f.			1	1													2
Alseodaphne untrinerved						1											1
Beilschmiedia glabra Kosterm.		1															1
Beilschmiedia madang Blume	1			1	1		1	2									6
Beilschmiedia sp.					2						1		10				13
Beilschmiedia sp.1												1					1
cf. Alseodaphne sp.															1		1
Cinnamomum inners Reinw. Ex Blume		1	1														2
Cinnamomum javanicum Blume							1										1
Cryptocarya impressa Miq.			1														1
Cryptocarya crassinervia Miq.							2	1							1		4
Cryptocarya ferrea Blume	2		2	1													5
Cryptocarya sp.										2			1			1	4
Cryptocarya sp. 4														1			1
Cryptocarya sp.1											1						1
Cryptocarya sp.2												1					1
Cryptocarya sp.3									1								1
Cryptocarya tomentosa Blume					3												3
Dehaasia elliptica Ridley	1			2													3
Dehaasia firma Blume	2				7	3	3										15
Dehaasia incrassata (Jack.) Kosterm.								1									1
Dehaasia sp.1											1	1		1			3
Dehaasia tomentosa Blume							1										1
Endiandra elongata Arifiani	1											1					2
Endiandra kingiana Gamble									1			2					3
Endiandra rubescens Blume ex Miq.	1				1	1	1										4
Endiandra sp.				1													1
Eusideroxylon zwageri Teijsm. & Binn.				1					6	6	11	5	5	4	2		40

	Lauraceae		1		1							1			1	1	1	6
	Litsea angulata Blume	1																1
	Litsea ferruginea Blume									1								1
	Litsea firma Hook. F.					2		1										3
	Litsea lanceifolia Hook. f.	1																1
	Litsea machilifolia Gamble					1	1	1										3
	Litsea noronhae Bl.	1																1
	Litsea oppositifolia L.S. Gibbs														2		1	3
	Litsea sessilis Boerl.						1		3									4
	Litsea sp.						2	1	1		1				2		4	11
	Litsea sp. 1						3		1									4
	Neolitsea sp.					1					1						2	4
	Nothaphoebe panduriformis Gamble									1								1
	Phoebe elliptica Blume								1									1
	Phoebe grandis (Nees.) Merrill						1											1
	Phoebe sp.							1										1
Lecythidaceae	*Barringtonia macrostachya Kurz*	1				7	1	2		1				1	2	1	1	17
	Barringtonia sp.	1																1
Leguminosae	*Afzelia rhamboidea F. Villar*															1	1	2
	Aganope sp.													2				2
	Archidendron ellipticum (Bl.) Nielsen								2									2
	Archidendron microcarpum (Bentham) I. Nielsen							1										1
	Archidendron sp.										1			3				4
	Archidendron sp. 1							1										1
	Cynometra ramiflora Miq.		3	2						1	3	3	1		2	2		17
	Cynometra sp. 1						2		6									8
	Dialium indum Linn			2		3	1	3	1	2	2	2	2		1	3	1	23
	Dialium kunstleri Prain														28	10	1	39
	Dialium maingayi					2		6										8
	Dialium modestum (v. Steenis) Steyaert.		2				1											3
	Dialium patens Baker	2	1		3													6
	Dialium platysepalum Baker	9			1							1	3	3	3		1	21
	Dialium sp.			1	1		1											3
	Fabaceae							1										1
	Fordia splendidissima (Blume ex Miq.) J. R. M.										7							7

	Buijsen																	
	Koompassia excelsa Taub.					1				2		1	1					5
	Koompassia malaccensis Maing.	4		4	2	3	1				1	3	1	2		2	3	26
	Parkia speciosa Hassk.			1					1	1	4	1	2		1			11
	Parkia timoriana Merrill													1				1
	Saraca declinata Miq.		3												1	2		6
	Saraca sp.													2				2
	Sindora leiocarpa Baker ex K.Heyne			1	1	5	2	1	1	2		1	1			1	1	17
	Sindora wallichii Benth.										2		1	1	1			5
Linaceae	*Ctenolophon parvifolius Oliver*	1				2	1	4										8
Loganiaceae	*Fagraea sp.*				1													1
Magnoliaceae	*Elmerillia tsiampacca (L.) Dandy*								1									1
	Magnolia candollii (Blume) H. P. Nooteboom			1			1						1	1	1			5
	Magnolia gigantifolia (Miq.) H. P. Nooteboom	1	4	3		2	1	1	2							1		15
	Magnolia lasia H. P. Noot.eboom									3		1	2	2	3	1	1	13
	Magnolia sp.												1					1
Melastomataceae	*Memecylon myrsinoides Blume*							1										1
	Memecylon borneense Merrill													1				1
	Memecylon costatum Miq.			2	1			1	1									5
	Memecylon edule Roxb.	1		1	1	2		2	2				1		1	1	6	18
	Memecylon floribundum Benth.					1												1
	Memecylon laurinum Blume	1	1	2														4
	Memecylon myrsinoides Blume						3	2										5
	Memecylon paniculatum Jack					2												2
	Memecylon sp.						4	1						2				7
	Pternandra azurea (Bl.) Burkill													1				1
	Pternandra caerulescens Jack			1	2		1			1	1						3	9
	pternandra galeata Ridley					1		2										3
	Pternandra rostrata (Cogn.) M. P. Nayar	4	3	8	6	1	1	15				1						39
	Pternandra sp.															1		1
Meliaceae	*Aglaia argentea Blume*									1								1
	Aglaia crassinervia Kurz ex Hiern										1					1	1	3
	Aglaia gigantea Pellegrin									1								1
	Aglaia leptantha Miq.								1							1		2
	Aglaia leucophylla King	1	1															2

	Aglaia macrocarpa (Miq.) C.M. Pannell	1																1
	Aglaia oligophylla Miq.				1				1									2
	Aglaia rubiginosa (Hiern.) C. M. Pannell							3										3
	Aglaia silvestris Merrill					1												1
	Aglaia simplicifolia Harms.	1		2														3
	Aglaia sp.	1			6		3	1		5	2	3		3	3			27
	Aglaia sp. 3										3		1		1	4	1	10
	Aglaia sp. 6										1				3			4
	Aglaia sp. 7														1			1
	Aglaia sp. 8															1		1
	Aglaia sp.1	1								1		1						3
	Aglaia sp.2										1							1
	Aglaia sp.4												2					2
	Aglaia sp.5										3							3
	Aglaia spectabilis (Miq.) S. S. Jain & S. S. R. Bennet																1	1
	Aglaia tomentosa Teijsm. & Binn.		2	1						1	1			2	2			9
	Chisocheton ceramicus Miq.														1			1
	Chisocheton macrophyllus King	1			1					1								3
	Chisocheton patens Blume			1	1		3			1	1	1						8
	Chisocheton pentandrus Merrill										1	1						2
	Chisocheton sp.									3	1	2			3	1		10
	Dysoxylum alliaceum Blume				1													1
	Dysoxylum sp.						3			2			1	1				7
	Dysoxylum sp.1					1					1						1	3
	Dysoxylum sp.2											1	2					3
	Reinwardtiodendron humile (Hassk.) D. J. Mabberley	1														1		2
	Sandoricum emarginatum Hiern							1										1
	Sandoricum koetjape Merrill														1			1
	Sandoricum sp.												1					1
	Walsura pinnata Hassk									1		1	2		1			5
	Walsura sp.												1	1				2
	Walsura sp.1												1					1
Moraceae	*Artocarpus anisophylla Miq.*					2		3										5
	Artocarpus dadah Miq.													1			2	3

	Artocarpus elasticus Reinw	1			1				4				2	1	1	1	1	12
	Artocarpus integer Merrill	1												2		2	3	8
	Artocarpus kemando Miq.	1					2	4	1									8
	Artocarpus lanceifolia Roxb.	8		9	12		4		2	11	9	11	5	12	14	12	7	116
	Artocarpus nitida Trec.		1	3							1			1				6
	Artocarpus nitida Trec. ssp. borneense														1	1	1	3
	Artocarpus nitida Trec. ssp. griffithii															2		2
	Artocarpus odoratissima Blanco					3									1	1		5
	Artocarpus sp.		3									1		2		1		7
	Artocarpus sp.1									1			1					2
	Artocarpus sp.2									1								1
	Artocarpus tamaran Becc.		1							3			1		1			6
	Ficus aurata Miq.																1	1
	Ficus grossularioides Burm. f.												2					2
	Ficus obscura Blume									3		3			2	1		9
	Ficus sp.	1	1										2		1			5
	Ficus sp.1									1					2			3
	Ficus uncinulata Corner								1									1
	Ficus vasculosa Wall.			1														1
	Parartocarpus bracteatus Becc.													1			1	2
	Parartocarpus venenosa Becc.				2		2	4										8
	Prainea limpato (Miq.) Beumee ex Heyne		1							3			2	1				7
	Streblus macrophyllus Blume														1			1
	Streblus sp. 1														8			8
	Streblus sp. 2														2			2
Myristicaceae	*Gymnacranthera contractaWarb.*				5	1	1											7
	Gymnacranthera eugeniifolia (A. DC.) J. Sincl. var. griffithii	5		1	2													8
	Gymnacranthera farquhariana Warb.									2	4	1		6		4	3	20
	Gymnacranthera forbesii Warb.															2	1	3
	Gymnacranthera ocellata R. T. A.Schouten												2					2
	Gymnacranthera sp.										1							1
	Horsfieldia crassifolia Warb.						1	4	1		2					2	3	13
	Horsfieldia glabra Warb.					1		2										3
	Horsfieldia grandis Warb.		1		3				1	1		1	1	1				9

Horsfieldia sp.				1		2					1			1			5
Horsfieldia sp. 1							1										1
Horsfieldia subglobosa Warb.						1											1
Horsfieldia wallichii Warb.			2							2	1	1		1		1	8
Knema cf. latericia															1		1
Knema cinerea (Poir) Warb. var. cordata		2	7														9
Knema cinerea (Poir) Warb. var. sumatrana		3		1													4
Knema cinerea (Poir.) Warb.	34	3	1	2	15	12	1	10									78
Knema conferta Warb.							1										1
Knema elliptica Warb.								1									1
Knema elmeri Merrill										1	4	3		1	6		15
Knema furfuracea Warb.	4	2	6	2	1	2		2									19
Knema galeata J. Sincl.								1					3				4
Knema glauca Warb.						2		4	1		1		4				12
Knema hirtela W. J. J. O. de Wilde														2	1		3
Knema korthalsii Warb.				1					1		1	5					8
Knema kurtisii Warb. var. arenosa														4			4
Knema latericia Elmer	2	2	1	5	4	1	1	2	2	2	2	1	6	5	6	2	44
Knema latifolia Warb.	1		1	3													5
Knema laurina Warb.		1	1	5	3	2	3	2					1	1	2	3	24
Knema lunduensis (Sinclair) W. J. J. O. de Wilde														1			1
Knema membranifolia H. Winkler		1															1
Knema palens W. J. J. O. de Wilde									3		5	3		2	1	7	21
Knema percoriacea J. Sincl.									1	1		1		1	2	2	8
Knema pulchra Warb.									3	3	1			5	5		17
Knema sp.		1				13			1		1		1	2	3	1	23
Knema sp.1						2	1	1	3		1						8
Knema woodii J. Sincl.														9		1	10
Myristica beccarii Warb.	2				5		9										16
Myristica crassa King	1	2															3
Myristica crassifolia Hook. f. & Thoms.							1										1
Myristica depressa W. J. J. O. de Wilde											1						1
Myristica iners Blume	6	3	10	7	3	3	2	9	3	6	1	1	1	2	4	2	63
Myristica maxima Warb.	2	2		1					5		1	1	1	1			14
Myristica sp.		1				9				1							11

	Myristica sp.1							1										1
	Myristica villosa Warb.	5		1	2		1	3		1	1							14
	Myristica wallichii Hook. f. et Thoms.	1																1
Myrsinaceae	*Ardisia fulginosa Blume*			2														2
	Ardisia gambleana Furtado					1			10									11
	Ardisia macrophylla Wall.								1									1
	Ardisia teysmanianna Scheff.					1												1
Myrtaceae	*Eugenia heteroclada Merrill*												1	3				4
	Rhodamnia cinerea Jack.					1												1
	Syzygium acutangulum Niedenzu	2																2
	Syzygium bankense (Hassk.) Merrill & Perry							4										4
	Syzygium baramense (Merrill) Merrill & Perry												3					3
	Syzygium caudatilimbum (Merrill) Merrill & Perry	1		3	4											1	1	10
	Syzygium chloranthum (Duthie) Merrill & Perry	1		3		2		10	1									17
	Syzygium confertum (Korth.) Merrill & Perry	4	1		2	3	1	1										12
	Syzygium exacavatum Wall.					1												1
	Syzygium fastigiatum (Blume) Merrill & Perry	1																1
	Syzygium grande Wall..	1			1	1	2											5
	Syzygium incarnata (Elmer) Merill & Perry					2		3										5
	Syzygium leptostemon (Korth.) Merrill & Perry	1																1
	Syzygium napiforme (Koord. & Valeton) Merrill & Perry									1								1
	Syzygium nigricans (King) Merrill & Perry													6				6
	Syzygium ochneocarpum (Merrill) Merrill & Perry	4	1	4	6	5		3								1	1	25
	Syzygium perpuncticulatum (Merrill) Merrill & Perry			1		1	1	2	4									9
	Syzygium picnanthum Merrill & Perry		7															7
	Syzygium prasiniflorum (Ridley) Merrill & Perry							2										2
	Syzygium sp.	6		3		5	16	11	4	2		2	2	4		2	1	58
	Syzygium sp.1				3	4		2	4	2	6	4	5			1		31
	Syzygium sp.10																1	1
	Syzygium sp.2						2		3		1				1			7
	Syzygium sp.3									1	2					1		4
	Syzygium sp.4										1				2	2	2	7
	Syzygium sp.5										2				2			4

	Syzygium sp.6											2						2
	Syzygium sp.7											2						2
	Syzygium sp.8											1						1
	Syzygium sp.9												1					1
	Syzygium stictophyllum Merrill & Perry	9	4	5	6				2									26
	Syzygium subcrenatum Merrill & Perry							1										1
	Syzygium tawahense (Korth.) Merrill & Perry	2								1				3			2	8
	Syzygium zeylanicum DC.	2			5													7
	Tristaniopsis whiteana (Griff.) P. G. Wilson & J. T. Waterhouse							1										1
Ochnaceae	*Gomphia serrata (Gaertn.) Kanis*	2		1		1		1			1					1		7
Olacaceae	*Ochanostachys amentacea Mast.*		1	4	3	1	1			2	6	1			1			20
	Scorodocarpus borneensis Becc.	2																2
	Strombosia ceylanica Gardn.		1												1	1		3
	Strombosia sp.									1								1
Oleaceae	*cf. Chionanthus sp.*												1					1
	Chionanthus curvicarpus R.Kiew											1						1
	Chionanthus cuspidatua Blume				1		1											2
	Chionanthus nitens Koord. & Valet.								2									2
	Chionanthus olingathus (Merrill) R. Kiew	1			1	3	4		1	1		2				1	3	17
	Chionanthus pubicalyx (Ridl.) R. Kiew	2				2	3											7
	Chionanthus sp.		1	1							2	1	3			2	2	12
	Chionanthus sp. 1								1									1
Oxalidaceae	*Sarcotheca diversifolia H. Hallier f.*	8			2	2		5			1	1		1			2	22
	Sarcotheca sp.													1				1
Podocarpaceae	*Podocarpus blumei Endl.*						1											1
	Podocarpus neriifolia D. Don							1										1
Polygalaceae	*Xanthophyllum affine Korth. ex. Miq.*			9	1						1	1			2	1		15
	Xanthophyllum amoenum Chod.															1		1
	Xanthophyllum cf. flavescens Roxb.	1	4	3	1													9
	Xanthophyllum cf. stapfii Chod.		1															1
	Xanthophyllum curtisii King		1															1
	Xanthophyllum ellipticum Korth. ex Miq.						1											1
	Xanthophyllum griffithii Hook. f. ex A. W. Benn.													1			1	2
	Xanthophyllum macrophyllum Baker														1	1		2

	Xanthophyllum obscurum A.W. Benn.				1							1		2	1	2		7
	Xanthophyllum parvum Chod.	8	5	10	3	5	1	6	2									40
	Xanthophyllum rufum A.W. Benn.				2	1				2			1	1			2	9
	Xanthophyllum scortechinii King				1													1
	Xanthophyllum sp.	1	1		2		5	1					1	1				12
	Xanthophyllum sp. 1						3	1		5	2	1	1			1		14
	Xanthophyllum sp. 2															2	1	3
	Xanthophyllum sp. 3														1			1
	Xanthophyllum stipitatum A.W.Benn.													2				2
Proteaceae	*Helicia fuscotomentosa Suesseng*							1										1
	Helicia petiolaris Benn.	3	1	2	1	2												9
	Helicia sp.													1		1		2
Rhamnaceae	*Ziziphus angustifolius(Miq.) Hatusima ex van Steenis*	1			1				2									4
	Ziziphus sp.												1					1
Rhizoporaceae	*Anisophyllea corneri Ding Hou*		2															2
	Carallia brachiata Merrill	1		2			1	1		2				2				9
	Gynotroches axilaris Blume		1							1			1					3
	Gynotroches sp.											1						1
Rosaceae	*Prunus arborea (Blume) Kalkm.*	2					1	1										4
	Prunus beccarii (Ridley.) Kalkm.																1	1
	Prunus sp.				1									4				5
	Prunus sp.1										1						1	2
	Prunus sp.2										1						3	4
	Rosaceae						1											1
Rubiaceae	*Adina polycephala Benth.*		2		1													3
	Anthocephalus cadamba Miq.					1	3		2	4	1	4	2			3		20
	cf. Pleiocarpidia sp.														1			1
	Gardenia sp.									1	1							2
	Gardenia tubifera Wall.	2	1										1		2		1	7
	Ixora brachyantha Merrill		4				1		7									12
	Ixora fluminalis Ridley									1	1	2	6			1	2	13
	Jackiopsis ornata (Wall.) C. E. Risdale						2	4										6
	Lasianthus sp.										1							1
	Maclurodendron porteri (Hook. f.) T. G. Hartley							1										1

	Nauclea sp.			1	1					1			2			2		7
	Neonauclea sp.														2			2
	Pleiocarpidia polyneura (Miq.) Bremek			1	1													2
	Pleiocarpidia sp.											1						1
	Porterandia anisophylla (Jack ex Roxb.) Ridley	1			1					3								5
	Rubiaceae					2					2							4
	Tarenna cumingiana Elmer														1			1
	Timonius borneensis Valet.							4	1									5
	Timonius lasianthoidesValet.									2		1	2					5
	Timonius sp.	1					1											2
	Timonius sp. 1				3													3
	Tricalysia malaccensis Merrill	3				4		1										8
	Urophyllum corymbosum Korth.					1			1									2
Rutaceae	*Tetractomia sp.*	3																3
	Tetractomia sp. 1							1										1
Sabiaceae	*Meliosma nitida Bl.*							1										1
	Meliosma sp.									1			1					2
Santalaceae	*Scleropyrum wallichianum A. Arn.*		2		1													3
Sapindaceae	*Dimocarpus dentatus W. Meijer ex Leenhouts*	1		4	1	1				1				3	3	5	2	21
	Lepisanthes alata (Blume) Leenh.		1															1
	Nephelium cuspidatum Blume			1	1		2				2		1					7
	Nephelium juglandifolium Blume				1													1
	Nephelium maingayi Hiern	2																2
	Nephelium mutabile Blume					4	1	2										7
	Nephelium ramboutan-ake (Labill.) P.W. Leenhouts				1									1				2
	Nephelium sp.	1									1						1	3
	Nephelium uncinatum Radlk.	3		6	4					1				9	1	2		26
	Paranephelium nitidum King									1					4	1		6
	Pometia alnifolia Radlk.				1													1
	Pometia pinnata G.Forst.				1			2	3	5			2					13
	Xerospermum laevigatum Radlk.						1											1
	Xerospermum noronhianum Blume			1											1	1		3
Sapotaceae	*Chrysophyllum roxburghii G. Don*									1								1
	Chrysophyllum sp.													1				1
	Madhuca borneensis van. Royen									1				6		2	2	11

	Madhuca cf. prolixa (Pierre ex Dubard) P.C.Yii & P. Chai		5	7	2													14
	Madhuca erythrophylla H. J. Lam							1										1
	Madhuca magnifica S. Moore					13		11										24
	Madhuca malaccensis H. J. Lam					1		2										3
	Madhuca mindanaensis Merrill									2		1	1		6	5		15
	Madhuca sericea H. J. Lam													3	1	2		6
	Madhuca sp.	1	2					1						11		3		18
	Madhuca sp.1								1									1
	Palaquium beccarianum (Pierre) van Royen													3	1			4
	Palaquium calophyllum Pierre ex Burck	3									2	1						6
	Palaquium cochleariifolium van Royen					1												1
	Palaquium dasyphyllum Pierre ex Dubard.		5		1				4									10
	Palaquium ferox H. J. Lam					4		1										5
	Palaquium gutta Burck				2			1										3
	Palaquium quercifolium Burck			10	5	4	1	2		1								23
	Palaquium rostratum Burck	4			6		2	8				1		2		2	5	30
	Palaquium sericeum H. J. Lam									3	6	4	2		1			16
	Palaquium sp.	1	1				1							3				6
	Palaquium sp.1							2	2									4
	Palaquium stenophyllum H. J. Lam			1						9	7	3	5	6	14	6	1	52
	Palaquium sumatranum Burck							1										1
	Payena lerii Kurz	1			1													2
	Payena lucida A. DC.											2						2
	Payena sp.						1				2							3
	Pouteria malaccensis (C. B. Clarke) Baehni	1					2											3
Simaroubaceae	*Allantospermum borneense Forman*													2				2
	Irvingia malayana Oliver					1	1	2			1	1		1		1		8
Sonneratiaceae	*Duabanga moluccana Blume*								1	1								2
Staphyliaceae	*Turpinia sphaerocarpa Hassk.*												1					1
Sterculiaceae	*Heritiera elata Ridley*	1		3	2				2	1							1	10
	Heritiera javanica (Blume) Kosterm.			1														1
	Heritiera simplicifolia (Mast.) Kosterm.					1								3		3	2	9
	Heritiera sp.															1		1
	Heritiera sumatrana (Miq.) Kosterm.	2	1		3			1	4	2	1							14

	Pterospermum javanicum Jungh.								1						3	1		5
	Scaphium borneense (Merrill) Kostermans													3				3
	Scaphium macropodum Beume ex K. Heyne	6		9	6		5	5	1	1	5	1	2		6	5	1	53
	Sterculia coccinea Jack							1	1									2
	Sterculia foeltida Linn.													12				12
	Sterculia macrophyllla Vent.															2		2
	Sterculia oblongata R. Br.	1			2													3
	Sterculia rubiginosa Vent.					1				1			1					3
	Sterculia sp.						1	1					1	2	1		2	8
	Sterculia sp.1							1		5	4	4				2		16
Styracaceae	*Bruinsmia styracoides Boerlage & Koorders*											1						1
Symplocaceae	*Symplocos cerasifolia Wall.*										3	2						5
	Symplocos cochinchinensis S. Moore	1		1														2
	Symplocos crassipes C. B.Clarke	1						1										2
	Symplocos fasciculata Roxb. ex A. DC.											1				1		2
	Symplocos rubiginosa Wall ex A. DC.		1															1
	Symplocos sp.			1			1										1	3
	Symplocos sp. 1								3									3
Theaceae	*Adinandra borneensis Kobuski*	1					6		6									13
	Adinandra subsessilis Airy Shaw									1	1	1	2			5	1	11
	Ternstroemia aneura Miq.					2		5										7
	Ternstroemia sp. 1								2									2
	Tetramerista glabra Miq.					1	3	9	1									14
Thymelaeaceae	*Aquilaria beccariana van Tiegh.*						1				1		1					3
	Aquilaria malaccensis Lam.			1		1							1	1	2			6
	Gonystylus affinis Radlk.											1			3	2	1	7
	Gonystylus forbesii Gilg.	1																1
	Gonystylus keithii Airy Shaw	1																1
	Gonystylus sp			1													2	3
	Gonystylus sp 1																1	1
Tiliaceae	*Brownlowia peltata Benth.*								1	1			1		3	2		8
	cf. Microcos sp.														1			1
	Grewia fibrocarpa Mast.									1					1			2
	Grewia sp.						1											1
	Grewia tomentosa Juss.						1											1

	Microcos cinnamomifolia (Burret) Stapf ex P.S.Ashton	3						1	1						1			6
	Microcos crassifolia Burret											1						1
	Microcos paniculata Burret		1															1
	Microcos tomentosa Sm.	2		1						1	1	1					1	7
	Pentace borneensis Pierre	3	1	6	5				4									19
	Pentace erectinervia Kosterm.												1					1
	Pentace laxiflora Merrill			4						3	4							11
	Pentace sp.													3				3
	Pentace sp. 1														2	5	7	14
	Pentace sp. 2														12	1		13
	Pentace sp. 3														1			1
	Pentace sp. 4																1	1
	Pentace triptera Mast.								1			1		1	4			7
Ulmaceae	*Gironniera nervosa Planch.*	3		2	1	3	1			2	4		2	9	1	2	4	34
	Gironniera subaequalis Planch.	1			1	3	2	1										8
Urticaceae	*Laportea oblanceolata Merrill*									1		1	3		4			9
Verbenaceae	*Geunsia pentandra Merrill*									7	2	2	1		2			14
	Teijsmanniodendron coriaceum (C.B. Clarke) Kosterm	4			2													6
	Teijsmanniodendron scaberrimum Kosterm.		4	2														6
	Teijsmanniodendron simplicifolium Merrill.		1			7	9	3	10									30
	Teijsmanniodendron simplicioides Kosterm.		10	3		1					1						1	16
	Teijsmanniodendron sp.													4			2	6
	Teijsmanniodendron sp.1									3		2	2		4	11	4	26
#N/A	*Unident 1*																5	5
	Unident 4					5	7									1		13
	Unident.2		2															2
	Unident.3		6															6
	Unident.5		1															1
Number of trees/Ha		635	571	571	644	452	468	522	561	437	536	504	527	567	558	616	565	8734
Number of species/Ha		196	160	175	187	165	174	193	178	173	157	160	175	162	185	197	170	914

#N/A	Dead trees	25	37	21	27	40	31	34	27	31	27	24	22	31	40	44	37	498

Appendix 3. Sapling species composition in a four 1-ha plots in primary and logged lowland forests in the Bulungan Research Forest-CIFOR, East Kalimantan.

Family	Species Name	PF	LF-5	LF-10	LF-30	Total
Actinidiaceae	*Saurauia sp,*			5	7	12
	Saurauia sp,1			1		1
	Saurauia subcordata Korth,	1				1
Alangiaceae	*Alangium javanicum (Blume) Wangerin*	3	1	1	2	7
	Alangium sp,			2	1	3
Anacardiaceae	*Buchanania arborescens F, Muell,*		3	3		6
	Buchanania sessifolia Blume	3	11	3		17
	Buchanania sp,			1		1
	Campnosperma auriculatum Hook, f,		2		4	6
	Campnosperma malayanum		1			1
	cf, Buchanania			1		1
	Dracontomelon dao Merrill & Rolfe		2			2
	Drimycarpus luridus (Hook,f,) Ding Hou	2			1	3
	Drimycarpus sp,			1		1
	Gluta wallichii (Hook, f,) Ding Hou	11	32	37	7	87
	Koordersiodendron pinnatum Merrill	1			2	3
	Mangifera magnifica K, M, Kochummen		1			1
	Mangifera sp,		1			1
	Mangifera sp, 1			1		1
	Mangifera swintonioides Kosterm	19	5	1		25
	Mangifera torquenda A, J, G, H, Kosterm		3			3
	Melanochyla (duri)			1		1
	Melanochyla elmeri Merrill	1				1
	Melanochyla fulvinervia (Blume) Ding Hou	1				1

	Melanochyla sp,			3	6	9
	Semecarpus burburyanus Gibbs	4	3		3	10
	Semecarpus sp, 1		2			2
	Swintonia glauca Engl,		2			2
Annonaceae	*cf, Popowia sp,*				3	3
	Cyathocalyx bancanus Boerl,		1			1
	Cyathocalyx carinatus (Ridley) J,Sincl,		3			3
	Cyathocalyx sp,			1		1
	Cyathocalyx sp, 1		4			4
	Goniothalamus cf, macrophyllus (Blume) Hook, f, & Thomson				2	2
	Goniothalamus macrophyllus (Blume) Hook, f, & Thomson			3		3
	Goniothalamus malayanus Hook,f, & Thomson	1	5			6
	Goniothalamus parallelovenius Ridley	1				1
	Goniothalamus sp,	1	1	6		8
	Goniothalamus sp,1			1		1
	Mezzettia parviflora Becc,		5		1	6
	Mitrephora korthalsiana Miq,		1			1
	Mitrephora sp,		2			2
	Mitrephora sp, 1		1			1
	Neouvaria	1				1
	Orophea sp, 1		1			1
	Polyalthia cauliflora Hook,f, & Thomson	38	2	1	9	50
	Polyalthia cf, rumphii Merrill				1	1
	Polyalthia lateriflora King	3		2		5
	Polyalthia microtus Miq,	1				1
	Polyalthia rumphii Merrill	2		3		5
	Polyalthia sp,	5	9	10	23	47
	Polyalthia sp,1		1			1
	Polyalthia sumatrana (Miq,) Kurz	9	20	3	1	33
	Popowia hirta Miq,		1			1
	Popowia pisocarpa (Blume) Endl,	1			2	3
	Popowia sp,			2	1	3

	Pseuduvaria reticulata Miq,	1				1
	Pseuduvaria rugosa (Blume) Merrill	1				1
	Sageraea elliptica Hook, f, & Thomson		1			1
	Sageraea lanceolata Miq,	1	4			5
	Sageraea sp,				1	1
	Uvaria sp,			1		1
	Xylopia caudata Hook, f, & Thomson	2	4			6
	Xylopia ferruginea Baill,		3			3
	Xylopia malayana Hook,f, & Thomson		2			2
	Xylopia sp, 1	6	1	1		8
	Xylopia sp, 2	1		12		13
Apocynaceae	*Alstonia angustifolia Wall,*		1			1
	Alstonia iwahigensis Elmer		1			1
	Alstonia scholaris (L,) R,Br,		1			1
	Kibatalia maingayi (Hook, f,) R, E, Woodson		2			2
	Kibatalia sp,			1		1
	Tabernaemontana macrocarpa Korth, ex Blume			1		1
Aquifoliaceae	*cf, Ilex*				1	1
	Ilex cymosa Blume		2			2
Bombacaceae	*Coelostegia sp,*	1				1
	Durio cf, kutejensis Becc,				1	1
	Durio dulcis Becc,			1		1
	Durio griffithii Bakh,	1				1
	Durio kutejensis Becc,			4		4
	Durio lanceolatus Mast,	2	3		1	6
	Durio oxleyanus Griff,				1	1
	Durio sp,	2			3	5
	Neesia altissima Blume		1			1
	Neesia synandra Mast,		2	2	1	5
Burseraceae	*Canarium costata (Benn,) H,J, Lam*	1				1
	Canarium littorale Blume		5		2	7
	Canarium odontophyllum Miq,			1		1
	Canarium pillosum A, W, Benn,	3	1			4
	Canarium sp,	2		8	8	18

	Canarium sp,1			4		4
	cf, Canarium sp,				1	1
	Dacryodes costata (A,W,Benn,) H,J, Lam	4	25	8		37
	Dacryodes crassipes Kalkman		4			4
	Dacryodes incurvata (Engl,) H, J, Lam	11	2		13	26
	Dacryodes laxa (A, W, Benn,) H, J, Lam	3	1		2	6
	Dacryodes rostrata (Blume) H, J, Lam forma pubescens	22	42	18	8	90
	Dacryodes rubiginosa (A, W, Benn,) H, J, Lam		2			2
	Dacryodes rugosa (Blume) H,J, Lam	33	8	5	12	58
	Dacryodes sp,	1		1		2
	Santiria apiculata A,W,Benn,		1			1
	Santiria griffithii Engl,		2	1		3
	Santiria laevigata Blume var, laevigata	1				1
	Santiria oblongifolia Blume		1			1
	Santiria rubiginosa Blume		3			3
	Santiria sp,			4	2	6
	Santiria tomentosa Blume	2	5			7
Celastraceae	*Bhesa paniculata Arn,*			1		1
	Euonymus	1				1
	Kokoona beccarii		3			3
	Kokoona littoralis M, A, Laws,		5			5
	Kokoona sp,	1				1
	Kokoona subobovata		1			1
	Lophopetalum beccarianum Pierre	59	1		4	64
	Lophopetalum cf, beccarianum Pierre	13				13
	Lophopetalum sp,			2	65	67
	Salacia sp,			1		1
	Siphonodon celastrineus Griff,		1			1
Chrysobalanaceae	*Atuna excelsa (Jack) Kosterm,*		4			4
	Atuna racemosa Rafin,		1		1	2
	Parastemon urophyllus A, X,		2			2
	Parinari oblongifolia Hook,f,		4			4
Connaraceae	*Ellipanthus tomentosus Kurz*	1		3	5	9

Convolvulaceae	*Erycibe glomerata Blume*	6	1			7
	Erycibe sp,	1				1
Cornaceae	*Mastixia rostrata Blume*		2			2
	Mastixia sp,			1		1
	Mastixia trichotoma Blume		3			3
Dilleniaceae	*Dillenia excelsa Martelli*	6	9	6	1	22
	Dillenia eximia Miq,		5			5
	Dillenia pentagyna Roxb,		13			13
	Dillenia sp,			2		2
	Dillenia suffruticosa (Griff,) Martelli			1		1
Dipterocarpaceae	*Anisoptera costata Korth,*	2		1		3
	Dipterocarpus crinitus Dyer		2			2
	Dipterocarpus elongatus Korth,	7				7
	Dipterocarpus eurynchus Miq,	32				32
	Dipterocarpus humeratus van Slooten			2		2
	Dipterocarpus lowii Hook, f,		8			8
	Dipterocarpus pachyphyllus Meyer	3				3
	Dipterocarpus sp,		1	4	16	21
	Dipterocarpus stellatus Vesque		12			12
	Dryobalanops elliptica	1				1
	Dryobalanops lanceolata Burck	9		50	1	60
	Hopea cernua Teijsm, & Binn,	19				19
	Hopea cf, cernua Teijsm, & Binn,				1	1
	Hopea cf, rudiformis P,S, Ashton				1	1
	Hopea dryobalanoides Miq,	1	13	14	130	158
	Hopea ferruginea Parijs	90	161			251
	Hopea mengerawan Miq,	4	1			5
	Hopea sp,	4			3	7
	Parashorea malaanonan Merrill	30	9	25	14	78
	Parashorea parvifolia Wyatt-Smith ex P, S, Ashton	1				1
	Parashorea sp,			2	1	3
	Shorea agami P, S, Ashton	13	2		3	18
	Shorea angustifolia P, S, Ashton	21			10	31
	Shorea atrinervosa Symington	1	4			5

Shorea beccarii Dyer ex Brandis	7	2		32	41
Shorea bracteolata Dyer,		2			2
Shorea cf, johorensis Foxworthy				1	1
Shorea cf, lamellata Foxworthy				2	2
Shorea cf, macroptera Dyer		1			1
Shorea cf, maxwelliana King	2				2
Shorea cf, obovoidea van Slooten	8				8
Shorea cf, ovalis Blume				2	2
Shorea cf, pinanga Scheff,	2				2
Shorea fallax Meijer		10			10
Shorea hopeifolia (Heim) Symington	5	2	6		13
Shorea inappendiculata Burck			7		7
Shorea johorensis Foxworthy	9	5	18	4	36
Shorea leprosula Miq,		2	2	6	10
Shorea macrocarpa	1	1			2
Shorea macroptera Dyer	81	23		2	106
Shorea maingayi		1			1
Shorea maxwelliana King	7			3	10
Shorea multiflora (Burck) Symington	1	2	18		21
Shorea ochracea Symington		2			2
Shorea ovalis Blume	5	8		2	15
Shorea parvifolia Dyer	74	66	157	7	304
Shorea parvistipulata Heim			18	2	20
Shorea patoiensis P, S, Ashton				5	5
Shorea pauciflora King	23	3	1	18	45
Shorea peltata Symington				13	13
Shorea pinanga Scheff,	28		5		33
Shorea sp,	21	10	19	24	74
Shorea sp, 2		18			18
Shorea sp,1		16	21		37
Shorea sp,3		24			24
Shorea venulosa G, H, S, Wood ex Meijer		1			1
Shorea xanthophylla Symington	48	1			49
Vatica albiramis v, Slooten	17	40			57

	Vatica cf, oblongifolia Hook, f,				1	1
	Vatica granulata v, Slooten	160	147			307
	Vatica micrantha v, Slooten		2		3	5
	Vatica oblongifolia Hook,f,	10	4	1		15
	Vatica rassak Blume		4			4
	Vatica sp,	4	2			6
	Vatica sp, 1		1			1
	Vatica umbonata Burck	29	1	1	9	40
	Vatica vinosa P,S, Ashton	9	1			10
Ebenaceae	*cf, Diospyros*	1		1		2
	Diospyros borneensis Hiern	8			4	12
	Diospyros buxifolia Hiern	4	10	2		16
	Diospyros cf, laevis Boj, ex A, DC,		1			1
	Diospyros cf, sumatrana Miq,			1		1
	Diospyros curraniopsis Bakh,	1				1
	Diospyros elliptifolia Merrill		5			5
	Diospyros foxworthyii Bakh,	8				8
	Diospyros frutescens Blume	1	4			5
	Diospyros oblonga Wall,	2				2
	Diospyros pilosanthera Blanco var,oblonga	5	4			9
	Diospyros sp,	22	22	24	39	107
	Diospyros sp, 4	1				1
	Diospyros sp, 6	1				1
	Diospyros sp,1		4	4		8
	Diospyros sp,2		6	1		7
	Diospyros sp,3		4			4
	Diospyros sp,5		3			3
	Diospyros sumatrana Miq,	47	10	6	7	70
	Diospyros wallichii King ex Gamble	2				2
Elaeocarpaceae	*Elaeocarpus pedunculatus Wall,*		1			1
	Elaeocarpus sp,			1	1	2
	Sloanea sp,				3	3
Euphorbiaceae	*Agrostistachys longifolia*		4			4
	Antidesma coriaceum Tul,		1			1

Antidesma grandistipulum Merrill		1			1
Antidesma neurocarpum Miq,	35	1			36
Antidesma sp,		1	2	2	5
Antidesma sp, 1			2	1	3
Antidesma tomentosum Blume	1	7			8
Aporosa antennifera (Airy Shaw) Airy Shaw		1			1
Aporosa bakonensis		1			1
Aporosa confusa Gage	1				1
Aporosa elmeri Merril,	5				5
Aporosa falcifera Hook, f,	1	2	1	1	5
Aporosa grandistipula Merrill	2		1		3
Aporosa lucida (Miq,) Airy Shaw	4	3			7
Aporosa nitida Merrill	3	5	9		17
Aporosa prainiana King ex Gage		15			15
Aporosa sp,	5	1	6	4	16
Aporosa sp, 1		4			4
Aporosa subcaudata Merrill	4	16	2	1	23
Baccaurea angulata Merrill		5	5		10
Baccaurea cf, sumatrana Muell, Arg,		1			1
Baccaurea edulis Merrill		6			6
Baccaurea javanica Muell, Arg,	6	3			9
Baccaurea kunstleri King ex Gage	1	1			2
Baccaurea macrocarpa Muell, Arg,	3		1		4
Baccaurea minor Hook, f,	2	6			8
Baccaurea minutiflora Muell, Arg,		2			2
Baccaurea pubera Muell, Arg,	2	1			3
Baccaurea sp,	8	12	10	1	31
Baccaurea sp,1		1			1
Baccaurea stipulata J, J, Smith	16	5			21
Baccaurea sumatrana Muell, Arg,		23			23
Baccaurea tetandra Muell, Arg,	1			1	2
Blumeodendron cf, tokbrai Kurz	2	1	2		5
Blumeodendron sp,			3	1	4
Bridelia glauca Blume				2	2

Cephalomappa beccariana Baill,	1				1
Cephalomappa lepidotula Airy Shaw		12			12
Cephalomappa sp,			1	2	3
cf, Cleistanthus sp,				2	2
Chaethocarpus castanocarpus Thw,		4			4
Claoxylon sp,			1		1
Cleistanthus bakonensis Airy Shaw		4			4
Cleistanthus glaucus		1			1
Cleistanthus myrianthus (Hassk,) Kurz	5	5		1	11
Cleistanthus sp,		1	5	12	18
Cleistanthus sp,1			8		8
Cleistanthus sp,2			2		2
Coccoceras borneense J, J, Smith,	4				4
Coccoceras sp,		1			1
Croton argyratus Blume		43			43
Croton sp,	12		2		14
Croton sp,1		1			1
Dimorphocalyx muricatus (Hook,f,) Airy Shaw	18				18
Drypetes kikir Airy Shaw	1			1	2
Drypetes laevis Pax et Hoffm,	2	3			5
Drypetes longifolia Pax & K, Hoffm,		1			1
Drypetes oblongifolia (Bedd,) Airy Shaw			5	3	8
Drypetes polyneura Airy Shaw	2			3	5
Drypetes sp,		3	1	1	5
Drypetes sp,1		1			1
Elateriospermum tapos Blume	3	4	22	1	30
Endospermum diadenum (Miq,) Airy Shaw		1			1
Galearia fulva (Tul,) miq,				1	1
Glochidion arborescens Blume	1	1			2
Glochidion borneensis Boerl,		13			13
Glochidion obscurum Blume		6			6
Glochidion rubrum Blume		2			2
Glochidion sericeum Zoll, & Mor,			3		3
Glochidion sp,		3	23	4	30

Glochidion superbum Baill,	1				1
Koilodepas brevipes Merr,	84	11	9	70	174
Macaranga bancana Muell, Arg,			66	6	72
Macaranga beccariana Merrill			5		5
Macaranga cf, depressa (Muell, Arg,) Muell, Arg,			17		17
Macaranga cf, lamellata Whitmore			2		2
Macaranga conifera (Zoll,) Muell, Arg,			1	4	5
Macaranga gigantea Muell, Arg,		21	1	1	23
Macaranga hypoleuca Muell, Arg,		10	27	1	38
Macaranga lowii King ex Hook,f,	8	9	1	5	23
Macaranga motleyana Muell, Arg,		14			14
Macaranga pearsonii Merrill		8	14		22
Macaranga pruinosa Muell, Arg,		24			24
Macaranga repando-dentata Airy Shaw		19			19
Macaranga sp,		1	10		11
Macaranga sp, 1		1	16		17
Macaranga winkleri Pax & K, Hoffm,		1	10		11
Mallotus cf, griffithianus (Muell, Arg,) Hook, f,			4	11	15
Mallotus dispar (Blume,) Muell, Arg,	3				3
Mallotus eucaustus Airy Shaw	30	22			52
Mallotus griffthianus Hook, f,				11	11
Mallotus korthalsii Muell, Arg,	2				2
Mallotus macrostachyus Muell, Arg,			3		3
Mallotus moritzianus Muell, Arg,	125	7			132
Mallotus muticus (Muell, Arg,) Airy Shaw		10	3		13
Mallotus penangensis Muell, Arg,	8	16	5	3	32
Mallotus repandus Muell, Arg,		4			4
Mallotus sp,			1		1
Mallotus sp, 1		3			3
Moultonianthus leembruggianus (Boerl, & Koord,) Steenis			1		1
Neoscortechinia kingii Pax & K, Hoffm,	1				1
Paracroton pendulus Miq,		5	5	1	11
Phyllanthus acida		1			1

	Phyllanthus emblica Linn,	2				2
	Pimelodendron griffithianum (Muell, Arg,) Hook, f,	3	4	1	2	10
	Ptychophyxsis	1				1
	Ptychopyxis bacciformis Croizat	1	1			2
	Ptychopyxis cf, arborea (Merr,) Airy Shaw		1			1
	Ptychopyxis sp,	7		2	3	12
	Ptychopyxis sp, 1		3	1		4
	Trigonopleura malayana Hook, f,	1	1			2
	Trigonostemon anomalus Merr,	1				1
	Trigonostemon elmeri Merr,	2				2
	Trigonostemon sp,	1	1	1		3
	Trigonostemon sp, 1		18			18
Fagaceae	*Castanopsis motleyana King*				1	1
	Castanopsis sp,	2			2	4
	Lithocarpus sp,		2			2
	Lithocarpus cantleyanus Rehder	2				2
	Lithocarpus cf, leptogyne (Korth,) Soepadmo	1				1
	Lithocarpus ewyckii Rehder		1			1
	Lithocarpus gracilis (Korth,) Soepadmo		10			10
	Lithocarpus nieuwenhuisii (Seem) A, Camus	1	4			5
	Lithocarpus sp, 3	2		9	3	14
	Lithocarpus sp,1		3			3
	Lithocarpus sp,2		1			1
	Lithocarpus urceolaris (Jack) Merrill		3			3
	Quercus argentata Korth,	1				1
	Quercus sp,	1				1
Flacourtiaceae	*cf, Hydnocarpus sp,*				1	1
	Flacourtia rukam Zoll, & Mor,			2		2
	Flacourtiaceae	1				1
	Homalium grandiflorum Benth,		1			1
	Hydnocarpus borneensis Sleumer	3	11			14
	Hydnocarpus kuenstleri Warb,	15	1			16
	Hydnocarpus polypetalus (v,Slooten) Sleum,	12				12
	Hydnocarpus sp,	23	1	1	6	31

	Hydnocarpus sp,1			1		1
	Hydnocarpus wodii Merrill	3	1	2		6
	Hydnocarpus wrayi King	8				8
	Ryparosa baccaureoides Sleum,	3	1			4
	Ryparosa caesia Kurz ex King		1			1
	Ryparosa sp,			1		1
Guttiferae	*Calophyllum cf, lowii Planch, & Triana*	1	3			4
	Calophyllum pulcherrimum Wall,		2			2
	Calophyllum sp,	1	1	1	2	5
	Calophyllum sp,1		1			1
	Calophyllum venulosum Zoll,	2				2
	Garcinia bancana (Miq,) Miq,		2			2
	Garcinia celebica L,		3			3
	Garcinia gaudichaudii Planch, & Triana		2			2
	Garcinia nervosa Miq,	1			1	2
	Garcinia parvifolia Miq,	5	3			8
	Garcinia penangiana Pierre	1	2			3
	Garcinia sp,	5	4	4	9	22
	Garcinia sp,1		3			3
	Garcinia sp,2		3			3
	Kayea borneensis P, F, Stevens	7		1	1	9
	Kayea sp, 1		1			1
	Mammea malayana Kosterm,	1				1
	Mammea sp,	1				1
	Mammea sp, 1	1				1
	Mesua acuminata Kosterm	1				1
	Mesua borneensis P,F, Stevens		9			9
	Mesua conoidea		3		1	4
	Mesua sp,	3			5	8
Hypericaceae	*Cratoxylum arborescens Blume*		1			1
	Cratoxylum formosum Benth, & Hook, f, ex Dyer		1	1		2
	Cratoxylum sumatranum Blume		2			2
Icacinaceae	*Gonocaryum gracile*		1			1
	Gonocaryum sp, 1		1			1

	Stemonurus grandifolius Becc,	5	1			6
	Stemonurus macrophyllus Blume		5			5
	Stemonurus scundiflorus Blume	4	11			15
	Stemonurus sp,	1		2	9	12
Lauraceae	*Actinodaphne glabra Blume*	1		1		2
	Actinodaphne glomerata Nees		5			5
	Actinodaphne sp,			2		2
	Actinodaphne sp,1		3			3
	Actinodaphne sphaerocarpa (Bl,) Nees,	1				1
	Alseodaphne / Dehaasia	1				1
	Alseodaphne cf, elmerii Merill	1				1
	Alseodaphne sp,	3	2	12	5	22
	Beilschmiedia glabra Kosterm,		1			1
	Beilschmiedia lucida (Miq,) Kosterm,		1			1
	Beilschmiedia madang Blume	3				3
	Beilschmiedia rubescens		1			1
	Beilschmiedia sp,1		5			5
	cf, Lauraceae				1	1
	cf, Litsea sp,				1	1
	Cinnamomum inners Reinw, Ex Blume	2	2	1		5
	Cinnamomum javanicum Blume		4			4
	Cinnamomum sp,			2		2
	Cryptocarya crassinervia Miq,		6		1	7
	Cryptocarya ferrea Blume	2	3			5
	Cryptocarya sp,	1		2	1	4
	Cryptocarya sp,1	1				1
	Cryptocarya tomentosa Blume		11			11
	Dehaasia crassifolia		1			1
	Dehaasia elliptica Ridley	2				2
	Dehaasia firma Blume		4			4
	Dehaasia incrassata (Jack,) Kosterm,		4			4
	Dehaasia sp,			1		1
	Dehaasia sp,1		2			2
	Dehaasia tomentosa Blume		2			2

	Endiandra rubescens Blume ex Miq,		3			3
	Endiandra sp,	2		2	1	5
	Eusideroxylon zwageri Teijsm, & Binn,		1	3		4
	Lauraceae		1	2	1	4
	Litsea firma Hook, F,		1			1
	Litsea glauca Siebold	4				4
	Litsea lanceifolia Hook, f,		2			2
	Litsea lanceifolia var lanceifolia	1				1
	Litsea noronhae Blume	1	1			2
	Litsea oppositifolia L,S, Gibbs	1		1		2
	Litsea resinosa Blume	1	1			2
	Litsea robusta Blume		1			1
	Litsea sessilis Boerl,		6			6
	Litsea sp,	4	2	9	2	17
	Litsea sp, 1		5			5
	Litsea urceolaris		1			1
	Phoebe elliptica Blume		1			1
	Phoebe grandis (Nees,) Merrill	1				1
Lecythidaceae	*Barringtonia macrostachya Kurz*	3	8			11
	Barringtonia sp,			2		2
Leeaceae	*Leea indica (Burm,f,) Merr,*			1		1
	Leea sp,			2	1	3
	Leea sp, 1			1		1
Leguminosae	*Archidendron havilandii (Ridl,) I,C,Nielsen*		1			1
	Archidendron microcarpum (Bentham) I, Nielsen		3			3
	Archidendron sp,		1	3	1	5
	cf, Dialium				1	1
	Crudia teijsmannii de Wit		2			2
	Cynometra ramiflora Miq,	1				1
	Cynometra sp,			1		1
	Cynometra sp, 1		2			2
	Dialium indum Linn	3	2			5
	Dialium kunstleri Prain				21	21
	Dialium patens Baker		2			2

	Dialium platysepalum Baker	1	1	2		4
	Dialium sp,	1		1		2
	Dialium sp, 1		1			1
	Fordia splendidissima (Blume ex Miq,) J, R, M, Buijsen	9	3	12		24
	Koompassia excelsa Taub,			1		1
	Koompassia malaccensis Maing,	1	1	2		4
	Leguminosae		2		1	3
	Millettia atropurpurea		1			1
	Ormosia sumatrana Prain ex King		2			2
	Parkia speciosa Hassk,			6	2	8
	Saraca declinata Miq,	10			1	11
	Sindora leiocarpa Baker ex K,Heyne	4	2			6
	Sindora wallichii Benth,	1	3		1	5
Liliaceae	*Pleomele elliptica Thunb,*	2				2
Linaceae	*Ctenolophon parvifolius Oliver*		1			1
	Ixonanthes sp,			2		2
Loganiaceae	*Fagraea racemosa Jack ex Wall,*	1	2	1		4
Magnoliaceae	*Elmerrillia mollis Dandy*		5			5
	Elmerrillia tsiampacca (L,) Dandy		1	1		2
	Magnolia candollii (Blume) H, P, Nooteboom	2	5	1		8
	Magnolia gigantea	1	1			2
	Magnolia gigantifolia (Miq,) H, P, Nooteboom	7	11			18
	Magnolia lasia H, P, Noot,eboom			7	5	12
	Magnolia magnifica		1			1
	Magnolia sp,			3		3
Melastomataceae	*Melastoma malabathricum L,*		5			5
	Melastoma polyanthum Benth,		6			6
	Memecylon edule Roxb,	3	7			10
	Memecylon laurinum Blume	4				4
	Memecylon myrsinoides Blume	1	2			3
	Memecylon paniculatum Jack		1			1
	Memecylon sp,	2	1	1	4	8
	Pternandra caerulescens Jack	4	6	1		11
	Pternandra cordifolia Cogn,		1			1

	Pternandra galeata Ridley		6			6
	Pternandra rostrata (Cogn,) M, P, Nayar	10	33		6	49
	Pternandra sp,	1	1			2
Meliaceae	*Aglaia argentea Blume*			1		1
	Aglaia crassinervia Kurz ex Hiern		1			1
	Aglaia elliptica Blume,		1			1
	Aglaia leptantha Miq,	1	1			2
	Aglaia leucophylla King	3				3
	Aglaia odoratissima Blume,	2	1			3
	Aglaia oligophylla Miq,	2	2			4
	Aglaia rubiginosa (Hiern,) C, M, Pannell		2			2
	Aglaia silvestris Merrill		6			6
	Aglaia simplicifolia Harms,	3	3		2	8
	Aglaia sp,	15	3	38	8	64
	Aglaia sp,1		7			7
	Aglaia tomentosa Teijsm, & Binn,	2	6	8		16
	cf, Chisocheton				1	1
	Chisocheton ceramicus Miq,		8			8
	Chisocheton patens Blume		1			1
	Chisocheton pentandrus Merrill	2				2
	Chisocheton sp,			9	1	10
	Dysoxylum sp,	1	2	5		8
	Dysoxylum sp,1		6			6
	Lansium domesticum Correa		2			2
	Lansium sp,			1		1
	Meliaceae	1		1	1	3
	Sandoricum beccarianum				1	1
	Sandoricum sp,				2	2
	Walsura pinnata Hassk	1				1
	Walsura sp,	1				1
	Walsura sp,1		1			1
Moraceae	*Artocarpus sp, 1*		1			1
	Artocarpus elasticus Reinw			4	2	6
	Artocarpus integer Merrill				3	3

	Artocarpus kemando Miq,		1			1
	Artocarpus lanceifolius Roxb,	17	7	25	10	59
	Artocarpus nitidus Trec,	1				1
	Artocarpus sp,			3	3	6
	Artocarpus tamaran Becc,			7		7
	Ficus grossularioides Burm, f,				1	1
	Ficus obscura Blume		23	32	18	73
	Ficus sp,	5	3	15	14	37
	Ficus sp,1		1	17		18
	Ficus uncinulata Corner		2			2
	Ficus variegata Blume		1			1
	Parartocarpus sp,				2	2
	Prainea limpato (Miq,) Beumee ex Heyne	1				1
	Prainea sp,	1			1	2
	Streblus elongatus			1		1
Myristicaceae	*Gymnacranthera contractaWarb,*		4			4
	Gymnacranthera farquhariana Warb,			1		1
	Gymnacranthera sp,			2		2
	Gymnacranthera sp, 1	1				1
	Horsfieldia crassifolia Warb,		2			2
	Horsfieldia glabra Warb,		6			6
	Horsfieldia grandis Warb,	3	4			7
	Horsfieldia sp,			5	3	8
	Horsfieldia sp, 1		1			1
	Knema beccariana		1			1
	Knema cf, laurina Warb,	1				1
	Knema cinerea (Poir) Warb, var, cordata	6				6
	Knema cinerea (Poir,) Warb, var cinerea	51	29			80
	Knema furfuracea Warb,	6	4			10
	Knema galeata J, Sincl,		2			2
	Knema glauca Warb,		6			6
	Knema latericia Elmer	2	5			7
	Knema latifolia Warb,		1			1
	Knema laurina Warb,	17	2		1	20

	Knema membranifolia H, Winkler	1				1
	Knema sp,	19	1	43	44	107
	Knema sp,1		5			5
	Myristica beccariana		4			4
	Myristica beccarii Warb,		1			1
	Myristica cf, inners Blume			1		1
	Myristica iners Blume	12	6	1	1	20
	Myristica maxima Warb,			1		1
	Myristica sp,	1	2	2		5
	Myristica sp,1		4			4
	Myristica villosa Warb,	1				1
Myrsinaceae	*Ardisia anisophylla Reinw,*	2				2
	Ardisia gambleana Furt,	21	1			22
	Ardisia sp,	4	4	1		9
	Ardisia sp, 1		2			2
	Ardisia teysmanianna Scheff,		2			2
Myrtaceae	*cf, Syzygium sp,*				6	6
	Rhodamnia cinerea Jack,		1			1
	Syzygium bankense (Hassk,) Merrill & Perry		3			3
	Syzygium caudatilimbum (Merrill) Merrill & Perry	2	2			4
	Syzygium cf, chloranthum (Duthie) Merrill & Perry		5			5
	Syzygium chloranthum (Duthie) Merrill & Perry	2	93			95
	Syzygium confertum (Korth,) Merrill & Perry	6	9			15
	Syzygium creaghii (Ridley) Merrill & Perry		1			1
	Syzygium ochneocarpum (Merrill) Merrill & Perry	11	16			27
	Syzygium perpuncticulatum (Merril) Merrill & Perryl		15			15
	Syzygium prasiniflorum (Ridley) Merrill & Perry		2			2
	Syzygium pterophorum Merill & Perry	1				1
	Syzygium sp,	28	34	17	36	115
	Syzygium sp, 3			1		1
	Syzygium sp, 4	1				1
	Syzygium sp,1		25			25
	Syzygium sp,2		7			7
	Syzygium stictophyllum Merrill & Perry	20	3			23

	Tristaniopsis whiteana (Griff,) P, G, Wilson & J, T, Waterhouse		1			1
N/A	*Indet 1*		1		1	2
	Indet 2			2		2
	Indet 3		1			1
Ochnaceae	*Gomphia serrata (Gaertn,) Kanis*	1		1	1	3
Olacaceae	*Anacolosa frutescens (Blume) Blume*		1			1
	Ochanostachys amentacea Mast,	3	1	1		5
	Strombosia sp,			1		1
Oleaceae	*Chionanthus cuspidatus Blume*		5			5
	Chionanthus olingathus (Merrill) R, Kiew	4	3		3	10
	Chionanthus pluriflorus (Knobl,) R,Kiew,	1	3			4
	Chionanthus pubicalyx (Ridl,) R, Kiew	6	4			10
	Chionanthus sp,	3	1	22	3	29
	Chionanthus sp, 1		3			3
Piperaceae	*Piper sp,*			1		1
Polygalaceae	*cf, Xanthophyllum sp,*				3	3
	Xanthophyllum affine Korth, ex, Miq,	6	3			9
	Xanthophyllum cf, affine Korth, ex Miq,	4				4
	Xanthophyllum discolor Chodat		1			1
	Xanthophyllum flavescens Roxb,	1				1
	Xanthophyllum heterophyllum Meijden			1		1
	Xanthophyllum hypoleucum Merrill		2			2
	Xanthophyllum obscurum A,W, Benn,				1	1
	Xanthophyllum parvum Chod,	16	5			21
	Xanthophyllum rufum A,W, Benn,	9				9
	Xanthophyllum sp,	23	1	11	11	46
	Xanthophyllum sp, 1		3	6		9
	Xanthophyllum sp, 2			1		1
	Xanthophyllum sp, 3				1	1
	Xanthophyllum stapfii Chod,	1				1
	Xanthophyllum vitellinum (Blume) D,Dietr,		3			3
Proteaceae	*cf, Heliciopsis sp,*	1				1
	Helicia petiolaris Benn,	1	1			2

	Helicia sp,				1	1
	Heliciopsis artocarpoides (Elmer) Sleumer	2			1	3
Rhamnaceae	*Ziziphus sp,*			6		6
Rhizoporaceae	*Anisophyllea corneri Ding Hou*	1				1
	Anisophyllea disticha Baill,		7			7
	Anisophyllea sp, 1	2				2
	Anisophyllea sp, 2	1				1
	Gynotroches axilaris Blume		6			6
Rosaceae	*cf, Prunus sp,*				1	1
	Parinari sp,	1				1
	Prunus sp,	2		2	5	9
Rubiaceae	*Anthocephalus chinensis Walp,*		3	6	3	12
	Gaertnera vaginans (Blume) Merr,		1			1
	Gardenia sp,			4	1	5
	Gardenia tubifera Wall,		1		1	2
	Hypobathrum sp,			1	1	2
	Ixora brachyantha Merrill	7	5			12
	Ixora pseudojavanica Brem,	10				10
	Ixora sp,	3		1	2	6
	Ixora sp, 1			1		1
	Ixora stenophylla (Korth,) Kuntz	33	17			50
	Jackiopsis ornata (Wall,) C, E, Risdale		2			2
	Lasianthus borneensis Merrill		2			2
	Lasianthus sp,		2	4		6
	Lasianthus sp, 1		2			2
	Maclurodendron porteri (Hook, f,) T, G, Hartley		1			1
	Nauclea sp,			4		4
	Pleiocarpidia polyneura (Miq,) Bremek	2	1			3
	Pleiocarpidia sp,			1		1
	Porterandia anisophylla (Jack ex Roxb,) Ridley			2	1	3
	Praravinia megistocalyx Brem,	1				1
	Prismatomeris beccariana (Baill,) Johans	2	1			3
	Rothmannia sp,				1	1
	Rubiaceae	1	4	5		10

	Tarenna sp,			1		1
	Tarenna winkleri Val,	1				1
	Timonius borneensis Valet,		1			1
	Timonius flavescens (Jack) Baker		1			1
	Timonius hirsutus Merrill		2			2
	Timonius sp,	2		6	4	12
	Timonius stipularis		1			1
	Tricalysia malaccensis Merrill	1	1			2
	Tricalysia singularis K, Schum,		4			4
	Urophyllum corymbosum Korth,	29	4			33
	Urophyllum macrophyllum Korth,	37				37
	Urophyllum sp,	10		12	7	29
	Urophyllum sp, 1			2		2
	Urophyllum trifurcum Pearson ex King		1			1
	Wendlandia sp, 1		3			3
Rutaceae	*Citrus sp,*			1		1
	Melicope sp,		2			2
Sabiaceae	*cf, Meliosma*	1				1
	Meliosma nitida Blume		1			1
	Meliosma sp,	1		1		2
Santalaceae	*Scleropyrum wallichianum A, Arn,*		2			2
Sapindaceae	*Dimocarpus dentatus W, Meijer ex Leenhouts*		10	2	3	15
	Ganophyllum falcatum Blume		2			2
	Lepisanthes alata (Blume) Leenh,	1				1
	Lepisanthes amoena (Hassk,) Leenh,	1				1
	Lepisanthes tetraphylla (Vahl,) Radlk,	1				1
	Mischocarpus sp,	3		8	4	15
	Nephelium cuspidatum Blume		15			15
	Nephelium lappaceum L,			4		4
	Nephelium mutabile Blume		4			4
	Nephelium sp,	2		29	2	33
	Nephelium sp,1			1		1
	Nephelium uncinatum Radlk,	5	1	8	2	16
	Paranephelium nitidum King			16		16

	Pometia pinnata G,Forst,			2	4	6
	Sapindaceae			2		2
	Xerospermum noronhianum Blume		1			1
Sapotaceae	*Ganua*		1			1
	Ganua motleyana		1			1
	Madhuca beccariana			1		1
	Madhuca borneensis van, Royen			1		1
	Madhuca cf, prolixa (Pierre ex Dubard) P,C,Yii & P, Chai	2				2
	Madhuca elmeri Merr,	1				1
	Madhuca erythrophylla H, J, Lam		1			1
	Madhuca magnifica S, Moore		49			49
	Madhuca mindanaensis Merrill			1		1
	Madhuca motleyana (de Vriese) Baehni			1	2	3
	Madhuca prolixa (Pierre ex Dubard) P,C, Yii & P, Chai	6				6
	Madhuca sp,	14	5	4	13	36
	Madhuca sp, 2	1				1
	Madhuca sp,1	5				5
	Palaquium beccarianum		1			1
	Palaquium calophyllum Pierre ex Burck	5				5
	Palaquium cf, sericeum H, J, Lam			1		1
	Palaquium chrysophyllum		2			2
	Palaquium dasyphyllum Pierre ex Dubard,	11				11
	Palaquium gutta Burck		4			4
	Palaquium leiocarpum Boerl,				8	8
	Palaquium obovatum Engl,		2			2
	Palaquium quercifolium Burck	5	8			13
	Palaquium rostratum Burck	6	6		2	14
	Palaquium sericeum H, J, Lam			9		9
	Palaquium sp,	1	5	3		9
	Palaquium sp,1		6			6
	Palaquium stenophyllum H, J, Lam	2		15		17
	Pouteria malaccensis (C, B, Clarke) Baehni		5			5
Scrophulariaceae	*Bacopa tomentosa*		5			5

Simaroubaceae	*Eurycoma longifolia Jack*		2		1	3
	Irvingia malayana Oliver			1		1
Sterculiaceae	*Byttneria sp,*			6		6
	Heritiera elata Ridley	1			1	2
	Heritiera sp,	1				1
	Heritiera sumatrana (Miq,) Kosterm,	20	5		3	28
	Leptonychia heteroclita K, Schum,		1			1
	Pterospermum javanicum Jungh,				1	1
	Scaphium macropodum Beume ex K, Heyne	12	6	16	13	47
	Sterculia coccinea Jack	1	1			2
	Sterculia oblongifolia A, Cheval,	2				2
	Sterculia rubiginosa Vent,	2	2	5	4	13
	Sterculia sp,	1		2	2	5
	Sterculia sp,1			8	2	10
	Sterculia stipulata Korth,		2			2
Styracaceae	*Bruinsmia sp,*			1		1
Symplocaceae	*Symplocos*	4				4
	Symplocos cochinchinensis S, Moore		1	1		2
	Symplocos crassipes C, B,Clarke	3				3
	Symplocos rubiginosa Wall ex A, DC,	1	1			2
	Symplocos sp,	3	1	2	1	7
	Symplocos sp, 1		1			1
	Symplocos sp, 2	1				1
Theaceae	*Adinandra borneensis Kobuski*	2	20			22
	Adinandra sp,	3	1	2	1	7
	cf, Theaceae	1				1
	Pyrenaria sp,	5				5
	Ternstroemia aneura Miq,		1			1
	Tetramerista glabra Miq,		1			1
	Theaceae				1	1
Thymelaeaceae	*Aquilaria beccariana van Tiegh,*	1	1	2		4
	Aquilaria malaccensis Lam,	1	4		2	7
	Aquilaria sp		1			1
	Gonystylus affinis Radlk,				4	4

	Gonystylus brunnescens Airy Shaw	1				1
	Gonystylus sp	1		2		3
Tiliaceae	*Brownlowia peltata Benth,*	6	2	7	1	16
	Grewia paniculata Roxb,		1			1
	Grewia sp,			1		1
	Microcos cinnamomifolia (Burret) Stapf ex P,S,Ashton	2	4			6
	Microcos crassifolia Burret			3	1	4
	Microcos sp,			1		1
	Microcos tomentosa Sm,	4	3	4	3	14
	Pentace borneensis Pierre	24				24
	Pentace erectinervia Kosterm,			6		6
	Pentace laxiflora Merrill		1	5		6
	Pentace sp,	2		1	1	4
	Pentace triptera Mast,	2				2
	Tiliaceae		1			1
Trigoniaceae	*Trigoniastrum hypoleucum Miq,*	4				4
	Trigoniastrum sp,	1				1
Ulmaceae	*Gironniera nervosa Planch,*	2	10	3	2	17
Urticaceae	*Dendrocnide sp,*			7	5	12
	Dendrocnide stimulans (Lf,) Chew		1			1
	Laportea lanceolata		1			1
	Laportea lanceolata (Engl,) Chew		4			4
	Urticaceae 1			2		2
	Urticaceae 2			3		3
Verbenaceae	*Clerodendrum sp,*			1		1
	Geunsia pentandra Merrill			5		5
	Teijsmanniodendron bogoriense Koord,			1	2	3
	Teijsmanniodendron coriaceum (C,B, Clarke) Kosterm	2	25			27
	Teijsmanniodendron scaberrimum Kosterm,	6				6
	Teijsmanniodendron simplicifolium Merrill,	15	4			19
	Teijsmanniodendron simplicioides Kosterm,		4			4
	Teijsmanniodendron sp,	2		4	8	14
	Teijsmanniodendron sp,1			7		7
	Vitex gamosephala Griff,	1				1

	Vitex sp,			4		4
	Vitex vestita Moldenke			7		7
Number of saplings/0.2 Ha		2565	2553	1609	1153	7880
Number of species/0.2 Ha		351	462	270	207	802
#N/A	Dead saplings		3			3

Appendix 4. Sapling species composition in 1-ha plot of primary and logged lowland forests in the Bulungan Resarch Forest-CIFOR East Kalimantan.

Family	Species Name	PF				LF-5				LF-10				LF-30				Total
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Actinidiaceae	*Saurauia sp,*									1	2	1	1		5	2		12
	Saurauia sp,1											1						1
	Saurauia subcordata Korth,		1															1
Alangiaceae	*Alangium javanicum (Blume) Wangerin*	1		1	1		1					1				2		7
	Alangium sp,									1	1					1		3
Anacardiaceae	*Buchanania arborescens F, Muell,*								3		2	1						6
	Buchanania sessifolia Blume	3				5	2	4				3						17
	Buchanania sp,											1						1
	Campnosperma auriculatum Hook, f,							2							1	1	2	6
	Campnosperma malayanum						1											1
	cf, Buchanania											1						1
	Dracontomelon dao Merrill & Rolfe					1			1									2
	Drimycarpus luridus (Hook,f,) Ding Hou		1		1										1			3

	Drimycarpus sp,										1							1
	Gluta wallichii (Hook, f,) Ding Hou	5	1	2	3	10	5	13	4		6	29	2		4	3		87
	Koordersiodendron pinnatum Merrill				1												2	3
	Mangifera magnifica K, M, Kochummen							1										1
	Mangifera sp,								1									1
	Mangifera sp, 1												1					1
	Mangifera swintonioides Kosterm	6		3	10	3	1		1	1								25
	Mangifera torquenda A, J, G, H, Kosterm							3										3
	Melanochyla (duri)											1						1
	Melanochyla elmeri Merrill		1															1
	Melanochyla fulvinervia (Blume) Ding Hou				1													1
	Melanochyla sp,									1	1	1		1	3	2		9
	Semecarpus burburyanus Gibbs		4			1	2							1			2	10
	Semecarpus sp, 1						2											2
	Swintonia glauca Engl,							2										2
Annonaceae	*cf, Popowia sp,*													2			1	3
	Cyathocalyx bancanus Boerl,						1											1
	Cyathocalyx carinatus (Ridley) J,Sincl,						3											3
	Cyathocalyx sp,									1								1
	Cyathocalyx sp, 1					4												4
	Goniothalamus cf, macrophyllus (Blume) Hook, f, & Thomson														2			2
	Goniothalamus macrophyllus (Blume) Hook, f, & Thomson									1			2					3
	Goniothalamus malayanus Hook,f, & Thomson	1				1	2	2										6
	Goniothalamus parallelovenius Ridley		1															1
	Goniothalamus sp,	1					1			5		1						8
	Goniothalamus sp,1											1						1
	Mezzettia parviflora Becc,						2	3									1	6
	Mitrephora korthalsiana Miq,						1											1
	Mitrephora sp,								2									2
	Mitrephora sp, 1						1											1
	Neouvaria	1																1
	Orophea sp, 1					1												1

	Polyalthia cauliflora Hook,f, & Thomson	13		14	11		2			1				1	2	6		50
	Polyalthia cf, rumphii Merrill													1				1
	Polyalthia lateriflora King	1	1		1						2							5
	Polyalthia microtus Miq,	1																1
	Polyalthia rumphii Merrill	1	1									3						5
	Polyalthia sp,		1	2	2	4	1	1	3	1	3	2	4	5	14	2	2	47
	Polyalthia sp,1						1											1
	Polyalthia sumatrana (Miq,) Kurz	3	2	2	2	3	17				1	2					1	33
	Popowia hirta Miq,					1												1
	Popowia pisocarpa (Blume) Endl,		1												2			3
	Popowia sp,										1	1					1	3
	Pseuduvaria reticulata Miq,				1													1
	Pseuduvaria rugosa (Blume) Merrill				1													1
	Sageraea elliptica Hook, f, & Thomson							1										1
	Sageraea lanceolata Miq,		1			1		3										5
	Sageraea sp,																1	1
	Uvaria sp,									1								1
	Xylopia caudata Hook, f, & Thomson		2			2		2										6
	Xylopia ferruginea Baill,						3											3
	Xylopia malayana Hook,f, & Thomson					1	1											2
	Xylopia sp, 1	6					1					1						8
	Xylopia sp, 2		1							1	2	6	3					13
Apocynaceae	*Alstonia angustifolia Wall,*					1												1
	Alstonia iwahigensis Elmer						1											1
	Alstonia scholaris (L,) R,Br,								1									1
	Kibatalia maingayi (Hook, f,) R, E, Woodson					2												2
	Kibatalia sp,												1					1
	Tabernaemontana macrocarpa Korth, ex Blume									1								1
Aquifoliaceae	*cf, Ilex*														1			1
	Ilex cymosa Blume						1	1										2
Bombacaceae	*Coelostegia sp,*	1																1
	Durio cf, kutejensis Becc,															1		1
	Durio dulcis Becc,											1						1

	Durio griffithii Bakh,	1																1
	Durio kutejensis Becc,										1	3						4
	Durio lanceolatus Mast,	1			1	2		1						1				6
	Durio oxleyanus Griff,																1	1
	Durio sp,			1	1											1	2	5
	Neesia altissima Blume								1									1
	Neesia synandra Mast,						2					2		1				5
Burseraceae	*Canarium costata (Benn,) H,J, Lam*			1														1
	Canarium littorale Blume					2		3								1	1	7
	Canarium odontophyllum Miq,												1					1
	Canarium pillosum A, W, Benn,		1	1	1			1										4
	Canarium sp,	1			1						1	6	1		5	2	1	18
	Canarium sp,1									1		2	1					4
	cf, Canarium sp,														1			1
	Dacryodes costata (A,W,Benn,) H,J, Lam			1	3	6	18		1	4		3	1					37
	Dacryodes crassipes Kalkman					2		2										4
	Dacryodes incurvata (Engl,) H, J, Lam	11				1		1							1	7	5	26
	Dacryodes laxa (A, W, Benn,) H, J, Lam	3						1						1		1		6
	Dacryodes rostrata (Blume) H, J, Lam forma pubescens	10	10	1	1	18	9	8	7	2	6	7	3	2	2	3	1	90
	Dacryodes rubiginosa (A, W, Benn,) H, J, Lam							2										2
	Dacryodes rugosa (Blume) H,J, Lam	9	4	3	17	4		4		1		3	1	4	1	3	4	58
	Dacryodes sp,	1										1						2
	Santiria apiculata A,W,Benn,					1												1
	Santiria griffithii Engl,					1	1					1						3
	Santiria laevigata Blume var, laevigata			1														1
	Santiria oblongifolia Blume							1										1
	Santiria rubiginosa Blume					1		2										3
	Santiria sp,											1	3	2				6
	Santiria tomentosa Blume		2					5										7
Celastraceae	*Bhesa paniculata Arn,*									1								1
	Euonymus				1													1
	Kokoona beccarii							3										3

	Kokoona littoralis M, A, Laws,					5												5
	Kokoona sp,				1													1
	Kokoona subobovata					1												1
	Lophopetalum beccarianum Pierre			59				1						4				64
	Lophopetalum cf, beccarianum Pierre			13														13
	Lophopetalum sp,									1	1			2		23	40	67
	Salacia sp,											1						1
	Siphonodon celastrineus Griff,					1												1
Chrysobalanaceae	*Atuna excelsa (Jack) Kosterm,*					1	3											4
	Atuna racemosa Rafin,							1						1				2
	Parastemon urophyllus A, X,							2										2
	Parinari oblongifolia Hook,f,					1		3										4
Connaraceae	*Ellipanthus tomentosus Kurz*				1						1	1	1	1		1	3	9
Convolvulaceae	*Erycibe glomerata Blume*	1		4	1			1										7
	Erycibe sp,	1																1
Cornaceae	*Mastixia rostrata Blume*						2											2
	Mastixia sp,												1					1
	Mastixia trichotoma Blume					1		2										3
Dilleniaceae	*Dillenia excelsa Martelli*		6				1	3	5		3	1	2			1		22
	Dillenia eximia Miq,						3		2									5
	Dillenia pentagyna Roxb,					13												13
	Dillenia sp,									2								2
	Dillenia suffruticosa (Griff,) Martelli										1							1
Dipterocarpaceae	*Anisoptera costata Korth,*			2								1						3
	Dipterocarpus crinitus Dyer							1	1									2
	Dipterocarpus elongatus Korth,		7															7
	Dipterocarpus eurynchus Miq,	7	5	12	8													32
	Dipterocarpus humeratus van Slooten												2					2
	Dipterocarpus lowii Hook, f,					2	3	2	1									8
	Dipterocarpus pachyphyllus Meyer		3															3
	Dipterocarpus sp,								1				4	5	6	3	2	21
	Dipterocarpus stellatus Vesque					4		6	2									12
	Dryobalanops elliptica			1														1
	Dryobalanops lanceolata Burck		6	3						1	6	38	5	1				60

Hopea cernua Teijsm, & Binn,	19																19
Hopea cf, cernua Teijsm, & Binn,															1		1
Hopea cf, rudiformis P,S, Ashton														1			1
Hopea dryobalanoides Miq,				1	8	3	1	1			8	6	45	3	22	60	158
Hopea ferruginea Parijs	7	43	39	1	94	55	8	4									251
Hopea mengerawan Miq,				4			1										5
Hopea sp,	1			3												3	7
Parashorea malaanonan Merrill		29		1		2		7	8	8	6	3		4	10		78
Parashorea parvifolia Wyatt-Smith ex P, S, Ashton		1															1
Parashorea sp,												2		1			3
Shorea agami P, S, Ashton	1		2	10		1	1						3				18
Shorea angustifolia P, S, Ashton	4			17									3		4	3	31
Shorea atrinervosa Symington				1		3	1										5
Shorea beccarii Dyer ex Brandis	1		2	4	1		1						3	3	21	5	41
Shorea bracteolata Dyer,						2											2
Shorea cf, johorensis Foxworthy															1		1
Shorea cf, lamellata Foxworthy														2			2
Shorea cf, macroptera Dyer					1												1
Shorea cf, maxwelliana King				2													2
Shorea cf, obovoidea van Slooten		8															8
Shorea cf, ovalis Blume															2		2
Shorea cf, pinanga Scheff,				2													2
Shorea fallax Meijer						8		2									10
Shorea hopeifolia (Heim) Symington		5				1		1			6						13
Shorea inappendiculata Burck									1			6					7
Shorea johorensis Foxworthy	9					2		3	1		16	1			4		36
Shorea leprosula Miq,					2				1		1			2	4		10
Shorea macrocarpa	1						1										2
Shorea macroptera Dyer	21	12	10	38	9		14									2	106
Shorea maingayi							1										1
Shorea maxwelliana King	4	3													2	1	10
Shorea multiflora (Burck) Symington	1					1		1		10	4	4					21
Shorea ochracea Symington						1	1										2

	Shorea ovalis Blume		5			2	1	2	3							2		15
	Shorea parvifolia Dyer	22	7	6	39	29	21	6	10	9	51	87	10			2	5	304
	Shorea parvistipulata Heim												18		2			20
	Shorea patoiensis P, S, Ashton													1			4	5
	Shorea pauciflora King	4	6		13			3		1							18	45
	Shorea peltata Symington															1	12	13
	Shorea pinanga Scheff,		27		1					3			2					33
	Shorea sp,	11	1	1	8	1	5	1	3	1	1	3	14	5	3	10	6	74
	Shorea sp, 2					6	6		6									18
	Shorea sp,1						13	3			20	1						37
	Shorea sp,3					23		1										24
	Shorea venulosa G, H, S, Wood ex Meijer							1										1
	Shorea xanthophylla Symington		39	2	7	1												49
	Vatica albiramis v, Slooten	7	10			29		11										57
	Vatica cf, oblongifolia Hook, f,															1		1
	Vatica granulata v, Slooten	54	68	36	2	64		16	67									307
	Vatica micrantha v, Slooten							2									3	5
	Vatica oblongifolia Hook,f,		7		3	2		2					1					15
	Vatica rassak Blume						2	2										4
	Vatica sp,	3			1			1	1									6
	Vatica sp, 1							1										1
	Vatica umbonata Burck	16		1	12				1		1			7		1	1	40
	Vatica vinosa P,S, Ashton				9				1									10
Ebenaceae	*cf, Diospyros*				1								1					2
	Diospyros borneensis Hiern	2	1	5										2		2		12
	Diospyros buxifolia Hiern		4			9			1				2					16
	Diospyros cf, laevis Boj, ex A, DC,								1									1
	Diospyros cf, sumatrana Miq,												1					1
	Diospyros curraniopsis Bakh,				1													1
	Diospyros elliptifolia Merrill						1	3	1									5
	Diospyros foxworthyii Bakh,		8															8
	Diospyros frutescens Blume				1		2	2										5
	Diospyros oblonga Wall,		2															2
	Diospyros pilosanthera Blanco var,oblonga		5			1	1		2									9

	Diospyros sp,	6	5	5	6	1	4	1	16	3	6	9	6	4	27		8	107
	Diospyros sp, 4	1																1
	Diospyros sp, 6				1													1
	Diospyros sp,1						1	3					4					8
	Diospyros sp,2					1	1	1	3		1							7
	Diospyros sp,3							4										4
	Diospyros sp,5					2	1											3
	Diospyros sumatrana Miq,	1	42	4			5		5	2	2		2		7			70
	Diospyros wallichii King ex Gamble		1	1														2
Elaeocarpaceae	*Elaeocarpus pedunculatus Wall,*							1										1
	Elaeocarpus sp,										1				1			2
	Sloanea sp,														1	2		3
Euphorbiaceae	*Agrostistachys longifolia*							4										4
	Antidesma coriaceum Tul,							1										1
	Antidesma grandistipulum Merrill						1											1
	Antidesma neurocarpum Miq,	8	3	11	13			1										36
	Antidesma sp,						1			1			1		1		1	5
	Antidesma sp, 1									1		1		1				3
	Antidesma tomentosum Blume		1			2	2	1	2									8
	Aporosa antennifera (Airy Shaw) Airy Shaw					1												1
	Aporosa bakonensis							1										1
	Aporosa confusa Gage		1															1
	Aporosa elmeri Merril,	1	4															5
	Aporosa falcifera Hook, f,			1			2					1				1		5
	Aporosa grandistipula Merrill	1	1							1								3
	Aporosa lucida (Miq,) Airy Shaw	1		1	2	1		2										7
	Aporosa nitida Merrill	1	1	1		1	1		3	2	1	3	3					17
	Aporosa prainiana King ex Gage					4		11										15
	Aporosa sp,	1		1	3				1		4	1	1		3		1	16
	Aporosa sp, 1						3	1										4
	Aporosa subcaudata Merrill	1		3		5	3	8			2					1		23
	Baccaurea angulata Merrill						1		4			5						10
	Baccaurea cf, sumatrana Muell, Arg,					1												1
	Baccaurea edulis Merrill						2	2	2									6

Baccaurea javanica Muell, Arg,	1		5			1		2									9
Baccaurea kunstleri King ex Gage				1		1											2
Baccaurea macrocarpa Muell, Arg,		3									1						4
Baccaurea minor Hook, f,		2			1	3	2										8
Baccaurea minutiflora Muell, Arg,					1		1										2
Baccaurea pubera Muell, Arg,				2			1										3
Baccaurea sp,	4	1		3		4		8		2	5	3	1				31
Baccaurea sp,1						1											1
Baccaurea stipulata J, J, Smith		13	3		3		2										21
Baccaurea sumatrana Muell, Arg,					6	3	14										23
Baccaurea tetandra Muell, Arg,	1														1		2
Blumeodendron cf, tokbrai Kurz	2							1			2						5
Blumeodendron sp,										1	1	1			1		4
Bridelia glauca Blume															2		2
Cephalomappa beccariana Baill,	1																1
Cephalomappa lepidotula Airy Shaw					7		5										12
Cephalomappa sp,									1				1			1	3
cf, Cleistanthus sp,														2			2
Chaethocarpus castanocarpus Thw,					2	1	1										4
Claoxylon sp,												1					1
Cleistanthus bakonensis Airy Shaw					3		1										4
Cleistanthus glaucus							1										1
Cleistanthus myrianthus (Hassk,) Kurz		5			2	1	2						1				11
Cleistanthus sp,							1		3	1	1		5	4	1	2	18
Cleistanthus sp,1									1		2	5					8
Cleistanthus sp,2												2					2
Coccoceras borneense J, J, Smith,		4															4
Coccoceras sp,						1											1
Croton argyratus Blume					43												43
Croton sp,	12									2							14
Croton sp,1							1										1
Dimorphocalyx muricatus (Hook,f,) Airy Shaw	1	17															18
Drypetes kikir Airy Shaw				1												1	2

Drypetes laevis Pax et Hoffm,	2				3												5
Drypetes longifolia Pax & K, Hoffm,						1											1
Drypetes oblongifolia (Bedd,) Airy Shaw									1	1	1	2	1			2	8
Drypetes polyneura Airy Shaw			2										1			2	5
Drypetes sp,								3		1			1				5
Drypetes sp,1						1											1
Elateriospermum tapos Blume			3		4				6	10	6		1				30
Endospermum diadenum (Miq,) Airy Shaw								1									1
Galearia fulva (Tul,) miq,														1			1
Glochidion arborescens Blume	1						1										2
Glochidion borneensis Boerl,					3	4	2	4									13
Glochidion obscurum Blume						6											6
Glochidion rubrum Blume					1		1										2
Glochidion sericeum Zoll, & Mor,												3					3
Glochidion sp,						3			1	4	10	8		4			30
Glochidion superbum Baill,	1																1
Koilodepas brevipes Merr,	15	7	39	23	2	7		2	3	1	1	4	18	38	6	8	174
Macaranga bancana Muell, Arg,									4	12	32	18			6		72
Macaranga beccariana Merrill												5					5
Macaranga cf, depressa (Muell, Arg,) Muell, Arg,												17					17
Macaranga cf, lamellata Whitmore												2					2
Macaranga conifera (Zoll,) Muell, Arg,										1					1	3	5
Macaranga gigantea Muell, Arg,					5	2		14		1						1	23
Macaranga hypoleuca Muell, Arg,					9	1			1	11	5	10			1		38
Macaranga lowii King ex Hook,f,	4			4	5		4					1			2	3	23
Macaranga motleyana Muell, Arg,					7	1	5	1									14
Macaranga pearsonii Merrill						5		3	1	7	4	2					22
Macaranga pruinosa Muell, Arg,					1	1		22									24
Macaranga repando-dentata Airy Shaw					3		16										19
Macaranga sp,						1				2		8					11
Macaranga sp, 1						1				12	1	3					17
Macaranga winkleri Pax & K, Hoffm,						1			2	1		7					11
Mallotus cf, griffithianus (Muell, Arg,) Hook,										2	2				4	7	15

	f,																
	Mallotus dispar (Blume,) Muell, Arg,	3															3
	Mallotus eucaustus Airy Shaw	30				9		13									52
	Mallotus griffthianus Hook, f,													11			11
	Mallotus korthalsii Muell, Arg,		2														2
	Mallotus macrostachyus Muell, Arg,										1	2					3
	Mallotus moritzianus Muell, Arg,	1		83	41	5	1		1								132
	Mallotus muticus (Muell, Arg,) Airy Shaw						9		1				3				13
	Mallotus penangensis Muell, Arg,		2	4	2	12		2	2		1	1	3	3			32
	Mallotus repandus Muell, Arg,					1		3									4
	Mallotus sp,									1							1
	Mallotus sp, 1					1	2										3
	Moultonianthus leembruggianus (Boerl, & Koord,) Steenis												1				1
	Neoscortechinia kingii Pax & K, Hoffm,				1												1
	Paracroton pendulus Miq,					3	2				4		1	1			11
	Phyllanthus acida					1											1
	Phyllanthus emblica Linn,			1	1												2
	Pimelodendron griffithianum (Muell, Arg,) Hook, f,	1	1	1		3		1		1				1		1	10
	Ptychophyxsis	1															1
	Ptychopyxis bacciformis Croizat			1					1								2
	Ptychopyxis cf, arborea (Merr,) Airy Shaw							1									1
	Ptychopyxis sp,				7					2					2	1	12
	Ptychopyxis sp, 1					1	1	1		1							4
	Trigonopleura malayana Hook, f,				1	1											2
	Trigonostemon anomalus Merr,			1													1
	Trigonostemon elmeri Merr,		2														2
	Trigonostemon sp,		1				1						1				3
	Trigonostemon sp, 1					16	2										18
Fagaceae	*Castanopsis motleyana King*															1	1
	Castanopsis sp,				2									2			4
	Lithocarpus sp,								2								2
	Lithocarpus cantleyanus Rehder				2												2

	Lithocarpus cf, leptogyne (Korth,) Soepadmo				1													1
	Lithocarpus ewyckii Rehder							1										1
	Lithocarpus gracilis (Korth,) Soepadmo					3	1	4	2									10
	Lithocarpus nieuwenhuisii (Seem) A, Camus				1		4											5
	Lithocarpus sp, 3		1	1							3	4	2			1	2	14
	Lithocarpus sp,1					1	2											3
	Lithocarpus sp,2						1											1
	Lithocarpus urceolaris (Jack) Merrill					1	1		1									3
	Quercus argentata Korth,				1													1
	Quercus sp,	1																1
Flacourtiaceae	*cf, Hydnocarpus sp,*													1				1
	Flacourtia rukam Zoll, & Mor,											1	1					2
	Flacourtiaceae				1													1
	Homalium grandiflorum Benth,					1												1
	Hydnocarpus borneensis Sleumer	1		2		2	3		6									14
	Hydnocarpus kuenstleri Warb,		2	1	12	1												16
	Hydnocarpus polypetalus (v,Slooten) Sleum,	1		4	7													12
	Hydnocarpus sp,	3	1	8	11				1			1		2	3	1		31
	Hydnocarpus sp,1												1					1
	Hydnocarpus wodii Merrill	1		2				1		1			1					6
	Hydnocarpus wrayi King		2	5	1													8
	Ryparosa baccaureoides Sleum,			3					1									4
	Ryparosa caesia Kurz ex King								1									1
	Ryparosa sp,									1								1
Guttiferae	*Calophyllum cf, lowii Planch, & Triana*				1			3										4
	Calophyllum pulcherrimum Wall,						2											2
	Calophyllum sp,			1				1				1					2	5
	Calophyllum sp,1							1										1
	Calophyllum venulosum Zoll,	1		1														2
	Garcinia bancana (Miq,) Miq,							1	1									2
	Garcinia celebica L,						2		1									3
	Garcinia gaudichaudii Planch, & Triana					1		1										2
	Garcinia nervosa Miq,		1													1		2
	Garcinia parvifolia Miq,	1		2	2	1	1		1									8

	Garcinia penangiana Pierre				1			2										3
	Garcinia sp,	3			2	1			3	1	1		2	4	1	2	2	22
	Garcinia sp,1							2	1									3
	Garcinia sp,2					1			2									3
	Kayea borneensis P, F, Stevens	1	6										1			1		9
	Kayea sp, 1						1											1
	Mammea malayana Kosterm,		1															1
	Mammea sp,		1															1
	Mammea sp, 1		1															1
	Mesua acuminata Kosterm				1													1
	Mesua borneensis P,F, Stevens						1	1	7									9
	Mesua conoidea						1	2						1				4
	Mesua sp,			1	2											4	1	8
Hypericaceae	*Cratoxylum arborescens Blume*					1												1
	Cratoxylum formosum Benth, & Hook, f, ex Dyer								1				1					2
	Cratoxylum sumatranum Blume					2												2
Icacinaceae	*Gonocaryum gracile*					1												1
	Gonocaryum sp, 1					1												1
	Stemonurus grandifolius Becc,			1	4			1										6
	Stemonurus macrophyllus Blume					4		1										5
	Stemonurus scundiflorus Blume		1		3	1		3	7									15
	Stemonurus sp,	1									1		1	3		2	4	12
Lauraceae	*Actinodaphne glabra Blume*				1						1							2
	Actinodaphne glomerata Nees					3		2										5
	Actinodaphne sp,												2					2
	Actinodaphne sp,1							3										3
	Actinodaphne sphaerocarpa (Bl,) Nees,			1														1
	Alseodaphne / Dehaasia				1													1
	Alseodaphne cf, elmerii Merill	1																1
	Alseodaphne sp,	2	1			1		1		1		5	6		2	2	1	22
	Beilschmiedia glabra Kosterm,								1									1
	Beilschmiedia lucida (Miq,) Kosterm,							1										1
	Beilschmiedia madang Blume		3															3

Beilschmiedia rubescens							1									1
Beilschmiedia sp,1					2	1	1	1								5
cf, Lauraceae													1			1
cf, Litsea sp,													1			1
Cinnamomum inners Reinw, Ex Blume		2					2			1						5
Cinnamomum javanicum Blume						1	3									4
Cinnamomum sp,										1	1					2
Cryptocarya crassinervia Miq,					2		4					1				7
Cryptocarya ferrea Blume			2			1		2								5
Cryptocarya sp,	1										2			1		4
Cryptocarya sp,1				1												1
Cryptocarya tomentosa Blume					10		1									11
Dehaasia crassifolia							1									1
Dehaasia elliptica Ridley	1			1												2
Dehaasia firma Blume						2	2									4
Dehaasia incrassata (Jack,) Kosterm,					1	3										4
Dehaasia sp,										1						1
Dehaasia sp,1					2											2
Dehaasia tomentosa Blume							2									2
Endiandra rubescens Blume ex Miq,								3								3
Endiandra sp,	2									1	1			1		5
Eusideroxylon zwageri Teijsm, & Binn,						1			1	1	1					4
Lauraceae						1					2			1		4
Litsea firma Hook, F,					1											1
Litsea glauca Siebold				4												4
Litsea lanceifolia Hook, f,						2										2
Litsea lanceifolia var lanceifolia	1															1
Litsea noronhae Blume			1			1										2
Litsea oppositifolia L,S, Gibbs	1								1							2
Litsea resinosa Blume			1				1									2
Litsea robusta Blume							1									1
Litsea sessilis Boerl,					2	1	3									6
Litsea sp,	1		1	2		1		1	1	7	1				2	17
Litsea sp, 1					1	4										5

	Litsea urceolaris							1									1
	Phoebe elliptica Blume					1											1
	Phoebe grandis (Nees,) Merrill			1													1
Lecythidaceae	*Barringtonia macrostachya Kurz*	2			1	1	6	1									11
	Barringtonia sp,												2				2
Leeaceae	*Leea indica (Burm,f,) Merr,*									1							1
	Leea sp,												2		1		3
	Leea sp, 1									1							1
Leguminosae	*Archidendron havilandii (Ridl,) I,C,Nielsen*								1								1
	Archidendron microcarpum (Bentham) I, Nielsen					1		2									3
	Archidendron sp,								1	3				1			5
	cf, Dialium													1			1
	Crudia teijsmannii de Wit						2										2
	Cynometra ramiflora Miq,		1														1
	Cynometra sp,												1				1
	Cynometra sp, 1						1		1								2
	Dialium indum Linn	2		1				2									5
	Dialium kunstleri Prain													2	12	7	21
	Dialium patens Baker						2										2
	Dialium platysepalum Baker	1						1			2						4
	Dialium sp,				1							1					2
	Dialium sp, 1						1										1
	Fordia splendidissima (Blume ex Miq,) J, R, M, Buijsen		8	1					3	2	9		1				24
	Koompassia excelsa Taub,												1				1
	Koompassia malaccensis Maing,			1			1						2				4
	Leguminosae						1		1					1			3
	Millettia atropurpurea								1								1
	Ormosia sumatrana Prain ex King					2											2
	Parkia speciosa Hassk,									2	1	1	2		1	1	8
	Saraca declinata Miq,		10												1		11
	Sindora leiocarpa Baker ex K,Heyne	4				1			1								6
	Sindora wallichii Benth,	1					3							1			5

Liliaceae	*Pleomele elliptica Thunb,*				2													2
Linaceae	*Ctenolophon parvifolius Oliver*							1										1
	Ixonanthes sp,										1	1						2
Loganiaceae	*Fagraea racemosa Jack ex Wall,*			1				2				1						4
Magnoliaceae	*Elmerrillia mollis Dandy*						5											5
	Elmerrillia tsiampacca (L,) Dandy						1			1								2
	Magnolia candollii (Blume) H, P, Nooteboom	1		1			2	3		1								8
	Magnolia gigantea	1						1										2
	Magnolia gigantifolia (Miq,) H, P, Nooteboom	1	3		3	2	1	5	3									18
	Magnolia lasia H, P, Noot,eboom											3	4	1	2	2		12
	Magnolia magnifica							1										1
	Magnolia sp,											1	2					3
Melastomataceae	*Melastoma malabathricum L,*						5											5
	Melastoma polyanthum Benth,					3	3											6
	Memecylon edule Roxb,				3	1	2	2	2									10
	Memecylon laurinum Blume		1	3														4
	Memecylon myrsinoides Blume	1				1		1										3
	Memecylon paniculatum Jack							1										1
	Memecylon sp,	2				1					1			2	1	1		8
	Pternandra caerulescens Jack			4			6			1								11
	Pternandra cordifolia Cogn,								1									1
	Pternandra galeata Ridley							6										6
	Pternandra rostrata (Cogn,) M, P, Nayar	2	3		5	4	4	25						1		4	1	49
	Pternandra sp,	1					1											2
Meliaceae	*Aglaia argentea Blume*												1					1
	Aglaia crassinervia Kurz ex Hiern							1										1
	Aglaia elliptica Blume,								1									1
	Aglaia leptantha Miq,			1				1										2
	Aglaia leucophylla King			1	2													3
	Aglaia odoratissima Blume,		2				1											3
	Aglaia oligophylla Miq,		2				1		1									4
	Aglaia rubiginosa (Hiern,) C, M, Pannell							2										2
	Aglaia silvestris Merrill					3	1	1	1									6

	Aglaia simplicifolia Harms,	1			2	2	1									2		8
	Aglaia sp,	5	1	2	7	1			2	16	9	7	6	3	4	1		64
	Aglaia sp,1					1	4	2										7
	Aglaia tomentosa Teijsm, & Binn,			2			5		1	2	2	1	3					16
	cf, Chisocheton													1				1
	Chisocheton ceramicus Miq,						6		2									8
	Chisocheton patens Blume						1											1
	Chisocheton pentandrus Merrill		1		1													2
	Chisocheton sp,									1	1	3	4				1	10
	Dysoxylum sp,				1		1		1	1		3	1					8
	Dysoxylum sp,1						4	2										6
	Lansium domesticum Correa						1		1									2
	Lansium sp,												1					1
	Meliaceae				1					1						1		3
	Sandoricum beccarianum													1				1
	Sandoricum sp,																2	2
	Walsura pinnata Hassk			1														1
	Walsura sp,				1													1
	Walsura sp,1						1											1
Moraceae	*Artocarpus sp, 1*								1									1
	Artocarpus elasticus Reinw										1	1	2		2			6
	Artocarpus integer Merrill															2	1	3
	Artocarpus kemando Miq,							1										1
	Artocarpus lanceifolius Roxb,	6		5	6	1	4	1	1	4	8	9	4		3	3	4	59
	Artocarpus nitidus Trec,	1																1
	Artocarpus sp,										1	1	1	1	2			6
	Artocarpus tamaran Becc,											3	4					7
	Ficus grossularioides Burm, f,															1		1
	Ficus obscura Blume						1		22	16		6	10		12	4	2	73
	Ficus sp,	2		1	2	2	1			8	5		2		11	3		37
	Ficus sp,1						1			15		2						18
	Ficus uncinulata Corner					2												2
	Ficus variegata Blume						1											1
	Parartocarpus sp,														2			2

	Prainea limpato (Miq,) Beumee ex Heyne				1													1
	Prainea sp,			1												1		2
	Streblus elongatus												1					1
Myristicaceae	*Gymnacranthera contractaWarb,*							4										4
	Gymnacranthera farquhariana Warb,											1						1
	Gymnacranthera sp,									1	1							2
	Gymnacranthera sp, 1				1													1
	Horsfieldia crassifolia Warb,						1	1										2
	Horsfieldia glabra Warb,					1	3	2										6
	Horsfieldia grandis Warb,	1			2	1		2	1									7
	Horsfieldia sp,									1	2	2		1	1		1	8
	Horsfieldia sp, 1						1											1
	Knema beccariana					1												1
	Knema cf, laurina Warb,				1													1
	Knema cinerea (Poir) Warb, var, cordata		1	4	1													6
	Knema cinerea (Poir,) Warb, var cinerea	27	5	9	10	17	4	5	3									80
	Knema furfuracea Warb,			3	3		3		1									10
	Knema galeata J, Sincl,						1		1									2
	Knema glauca Warb,						4		2									6
	Knema latericia Elmer	1		1		3	1	1										7
	Knema latifolia Warb,						1											1
	Knema laurina Warb,	9	1	4	3		1	1							1			20
	Knema membranifolia H, Winkler			1														1
	Knema sp,	12		1	6				1	11	12	13	7	6	10	10	18	107
	Knema sp,1					1		4										5
	Myristica beccariana							4										4
	Myristica beccarii Warb,							1										1
	Myristica cf, inners Blume									1								1
	Myristica iners Blume	2	2	1	7		5		1	1						1		20
	Myristica maxima Warb,											1						1
	Myristica sp,		1				1		1				2					5
	Myristica sp,1						3	1										4
	Myristica villosa Warb,			1														1
Myrsinaceae	*Ardisia anisophylla Reinw,*				2													2

	Ardisia gambleana Furt,	1	6	8	6	1												22
	Ardisia sp,	4				1			3			1						9
	Ardisia sp, 1					1		1										2
	Ardisia teysmanianna Scheff,								2									2
Myrtaceae	*cf, Syzygium sp,*															3	3	6
	Rhodamnia cinerea Jack,					1												1
	Syzygium bankense (Hassk,) Merrill & Perry							3										3
	Syzygium caudatilimbum (Merrill) Merrill & Perry	1			1	1	1											4
	Syzygium cf, chloranthum (Duthie) Merrill & Perry							5										5
	Syzygium chloranthum (Duthie) Merrill & Perry			1	1			93										95
	Syzygium confertum (Korth,) Merrill & Perry		1		5		3	6										15
	Syzygium creaghii (Ridley) Merrill & Perry								1									1
	Syzygium ochneocarpum (Merrill) Merrill & Perry	5		4	2	6		10										27
	Syzygium perpuncticulatum (Merril) Merrill & Perryl					1	5	9										15
	Syzygium prasiniflorum (Ridley) Merrill & Perry							2										2
	Syzygium pterophorum Merill & Perry	1																1
	Syzygium sp,	15	2		11	4	12	3	15	4	3	9	1	13	10		13	115
	Syzygium sp, 3											1						1
	Syzygium sp, 4	1																1
	Syzygium sp,1					15	3	7										25
	Syzygium sp,2						1		6									7
	Syzygium stictophyllum Merrill & Perry	7	5	7	1		1		2									23
	Tristaniopsis whiteana (Griff,) P, G, Wilson & J, T, Waterhouse							1										1
N/A	*Indet 1*						1								1			2
	Indet 2									1			1					2
	Indet 3						1											1
Ochnaceae	*Gomphia serrata (Gaertn,) Kanis*	1										1					1	3
Olacaceae	*Anacolosa frutescens (Blume) Blume*					1												1
	Ochanostachys amentacea Mast,			3			1				1							5

	Strombosia sp,									1								1
Oleaceae	*Chionanthus cuspidatus Blume*						5											5
	Chionanthus olingathus (Merrill) R, Kiew	1	2	1		2	1							1	2			10
	Chionanthus pluriflorus (Knobl,) R,Kiew,			1			3											4
	Chionanthus pubicalyx (Ridl,) R, Kiew	3	3			2	1	1										10
	Chionanthus sp,	2		1					1	4	1	12	5		2		1	29
	Chionanthus sp, 1								3									3
Piperaceae	*Piper sp,*												1					1
Polygalaceae	*cf, Xanthophyllum sp,*														2	1		3
	Xanthophyllum affine Korth, ex, Miq,				6		2		1									9
	Xanthophyllum cf, affine Korth, ex Miq,				4													4
	Xanthophyllum discolor Chodat							1										1
	Xanthophyllum flavescens Roxb,			1														1
	Xanthophyllum heterophyllum Meijden												1					1
	Xanthophyllum hypoleucum Merrill							2										2
	Xanthophyllum obscurum A,W, Benn,													1				1
	Xanthophyllum parvum Chod,	2	2	2	10	2	3											21
	Xanthophyllum rufum A,W, Benn,	2	1	5	1													9
	Xanthophyllum sp,	7		3	13		1			2	1	4	4	4	4	2	1	46
	Xanthophyllum sp, 1					2	1			2			4					9
	Xanthophyllum sp, 2												1					1
	Xanthophyllum sp, 3													1				1
	Xanthophyllum stapfii Chod,			1														1
	Xanthophyllum vitellinum (Blume) D,Dietr,						3											3
Proteaceae	*cf, Heliciopsis sp,*	1																1
	Helicia petiolaris Benn,			1			1											2
	Helicia sp,																1	1
	Heliciopsis artocarpoides (Elmer) Sleumer			1	1												1	3
Rhamnaceae	*Ziziphus sp,*											2	4					6
Rhizoporaceae	*Anisophyllea corneri Ding Hou*		1															1
	Anisophyllea disticha Baill,					4		3										7
	Anisophyllea sp, 1	2																2
	Anisophyllea sp, 2	1																1
	Gynotroches axilaris Blume						4		2									6

Rosaceae	*cf, Prunus sp,*														1			1
	Parinari sp,			1														1
	Prunus sp,	2										2		1	1	1	2	9
Rubiaceae	*Anthocephalus chinensis Walp,*					1	1		1	5		1				3		12
	Gaertnera vaginans (Blume) Merr,							1										1
	Gardenia sp,										2		2	1				5
	Gardenia tubifera Wall,							1									1	2
	Hypobathrum sp,										1						1	2
	Ixora brachyantha Merrill	2	1	2	2		4		1									12
	Ixora pseudojavanica Brem,		2	4	4													10
	Ixora sp,	2			1							1					2	6
	Ixora sp, 1											1						1
	Ixora stenophylla (Korth,) Kuntz	5	3	2	23	7	8	2										50
	Jackiopsis ornata (Wall,) C, E, Risdale							2										2
	Lasianthus borneensis Merrill					1	1											2
	Lasianthus sp,					1		1		3		1						6
	Lasianthus sp, 1					1	1											2
	Maclurodendron porteri (Hook, f,) T, G, Hartley							1										1
	Nauclea sp,									1			3					4
	Pleiocarpidia polyneura (Miq,) Bremek		2				1											3
	Pleiocarpidia sp,									1								1
	Porterandia anisophylla (Jack ex Roxb,) Ridley											1	1			1		3
	Praravinia megistocalyx Brem,		1															1
	Prismatomeris beccariana (Baill,) Johans	1		1		1												3
	Rothmannia sp,															1		1
	Rubiaceae				1		2	1	1			1	4					10
	Tarenna sp,										1							1
	Tarenna winkleri Val,				1													1
	Timonius borneensis Valet,					1												1
	Timonius flavescens (Jack) Baker					1												1
	Timonius hirsutus Merrill							2										2
	Timonius sp,			2								1	5	1		3		12

	Timonius stipularis							1										1
	Tricalysia malaccensis Merrill	1					1											2
	Tricalysia singularis K, Schum,					1	3											4
	Urophyllum corymbosum Korth,	8	4	3	14			1	3									33
	Urophyllum macrophyllum Korth,		7	11	19													37
	Urophyllum sp,	6			4					3		3	6	1	2	1	3	29
	Urophyllum sp, 1									1	1							2
	Urophyllum trifurcum Pearson ex King						1											1
	Wendlandia sp, 1					3												3
Rutaceae	*Citrus sp,*												1					1
	Melicope sp,								2									2
Sabiaceae	*cf, Meliosma*	1																1
	Meliosma nitida Blume								1									1
	Meliosma sp,	1										1						2
Santalaceae	*Scleropyrum wallichianum A, Arn,*					2												2
Sapindaceae	*Dimocarpus dentatus W, Meijer ex Leenhouts*					1	4		5	1	1			1		1	1	15
	Ganophyllum falcatum Blume					2												2
	Lepisanthes alata (Blume) Leenh,		1															1
	Lepisanthes amoena (Hassk,) Leenh,		1															1
	Lepisanthes tetraphylla (Vahl,) Radlk,		1															1
	Mischocarpus sp,		3								1	5	2	2		2		15
	Nephelium cuspidatum Blume					1	12		2									15
	Nephelium lappaceum L,										4							4
	Nephelium mutabile Blume							3	1									4
	Nephelium sp,	2								5	7	5	12	1	1			33
	Nephelium sp,1										1							1
	Nephelium uncinatum Radlk,	5						1		1		7				1	1	16
	Paranephelium nitidum King												16					16
	Pometia pinnata G,Forst,									1	1				3	1		6
	Sapindaceae												2					2
	Xerospermum noronhianum Blume								1									1
Sapotaceae	*Ganua*						1											1
	Ganua motleyana						1											1
	Madhuca beccariana										1							1

	Madhuca borneensis van, Royen											1						1
	Madhuca cf, prolixa (Pierre ex Dubard) P,C,Yii & P, Chai			2														2
	Madhuca elmeri Merr,		1															1
	Madhuca erythrophylla H, J, Lam							1										1
	Madhuca magnifica S, Moore					14	4	31										49
	Madhuca mindanaensis Merrill										1							1
	Madhuca motleyana (de Vriese) Baehni												1	2				3
	Madhuca prolixa (Pierre ex Dubard) P,C, Yii & P, Chai		3	1	2													6
	Madhuca sp,	4	9		1				5			1	3	4	8		1	36
	Madhuca sp, 2				1													1
	Madhuca sp,1		3	2														5
	Palaquium beccarianum					1												1
	Palaquium calophyllum Pierre ex Burck			4	1													5
	Palaquium cf, sericeum H, J, Lam												1					1
	Palaquium chrysophyllum					2												2
	Palaquium dasyphyllum Pierre ex Dubard,		9	2														11
	Palaquium gutta Burck						2	1	1									4
	Palaquium leiocarpum Boerl,													1	5		2	8
	Palaquium obovatum Engl,								2									2
	Palaquium quercifolium Burck	2			3	1	1	1	5									13
	Palaquium rostratum Burck	1		2	3	1	2	3								1	1	14
	Palaquium sericeum H, J, Lam									5	3	1						9
	Palaquium sp,				1			3	2			1	2					9
	Palaquium sp,1						4		2									6
	Palaquium stenophyllum H, J, Lam				2					3	4	4	4					17
	Pouteria malaccensis (C, B, Clarke) Baehni						5											5
Scrophulariaceae	*Bacopa tomentosa*					5												5
Simaroubaceae	*Eurycoma longifolia Jack*							2						1				3
	Irvingia malayana Oliver											1						1
Sterculiaceae	*Byttneria sp,*										4		2					6
	Heritiera elata Ridley		1											1				2
	Heritiera sp,				1													1

	Heritiera sumatrana (Miq,) Kosterm,	12		3	5	1	2		2						1	2	28
	Leptonychia heteroclita K, Schum,						1										1
	Pterospermum javanicum Jungh,														1		1
	Scaphium macropodum Beume ex K, Heyne	7		2	3		6			4		10	2	4	6	3	47
	Sterculia coccinea Jack			1				1									2
	Sterculia oblongifolia A, Cheval,		2														2
	Sterculia rubiginosa Vent,		2				1		1	1		3	1	1	2	1	13
	Sterculia sp,	1											2		2		5
	Sterculia sp,1											6	2	2			10
	Sterculia stipulata Korth,								2								2
Styracaceae	*Bruinsmia sp,*									1							1
Symplocaceae	*Symplocos*	4															4
	Symplocos cochinchinensis S, Moore							1				1					2
	Symplocos crassipes C, B,Clarke	2		1													3
	Symplocos rubiginosa Wall ex A, DC,		1					1									2
	Symplocos sp,	1			2				1		1	1			1		7
	Symplocos sp, 1					1											1
	Symplocos sp, 2				1												1
Theaceae	*Adinandra borneensis Kobuski*		1		1	2	9		9								22
	Adinandra sp,	3							1		2				1		7
	cf, Theaceae				1												1
	Pyrenaria sp,			2	3												5
	Ternstroemia aneura Miq,							1									1
	Tetramerista glabra Miq,							1									1
	Theaceae														1		1
Thymelaeaceae	*Aquilaria beccariana van Tiegh,*		1				1			1	1						4
	Aquilaria malaccensis Lam,				1		1	3						1	1		7
	Aquilaria sp							1									1
	Gonystylus affinis Radlk,													1		3	4
	Gonystylus brunnescens Airy Shaw		1														1
	Gonystylus sp	1									2						3
Tiliaceae	*Brownlowia peltata Benth,*		5		1				2		1		6		1		16
	Grewia paniculata Roxb,								1								1
	Grewia sp,												1				1

	Microcos cinnamomifolia (Burret) Stapf ex P,S,Ashton	2				4												6
	Microcos crassifolia Burret										1		2			1		4
	Microcos sp,											1						1
	Microcos tomentosa Sm,	1	1	1	1	2		1		1	1	1	1		2		1	14
	Pentace borneensis Pierre	8		1	15													24
	Pentace erectinervia Kosterm,										5	1						6
	Pentace laxiflora Merrill						1				2	3						6
	Pentace sp,	2								1					1			4
	Pentace triptera Mast,			2														2
	Tiliaceae						1											1
Trigoniaceae	*Trigoniastrum hypoleucum Miq,*				4													4
	Trigoniastrum sp,	1																1
Ulmaceae	*Gironniera nervosa Planch,*	1		1		7	3			3				1		1		17
Urticaceae	*Dendrocnide sp,*											2	5		4	1		12
	Dendrocnide stimulans (Lf,) Chew								1									1
	Laportea lanceolata							1										1
	Laportea lanceolata (Engl,) Chew					4												4
	Urticaceae 1									2								2
	Urticaceae 2									3								3
Verbenaceae	*Clerodendrum sp,*										1							1
	Geunsia pentandra Merrill									2		3						5
	Teijsmanniodendron bogoriense Koord,												1		1		1	3
	Teijsmanniodendron coriaceum (C,B, Clarke) Kosterm		1	1		25												27
	Teijsmanniodendron scaberrimum Kosterm,		3		3													6
	Teijsmanniodendron simplicifolium Merrill,		9	6		1	1	2										19
	Teijsmanniodendron simplicioides Kosterm,					1	2		1									4
	Teijsmanniodendron sp,	1			1								4	2	2	2	2	14
	Teijsmanniodendron sp,1									5			2					7
	Vitex gamosephala Griff,			1														1
	Vitex sp,										1	3						4
	Vitex vestita Moldenke										4	3						7
Number of saplings/0.2 Ha		638	640	593	694	815	615	670	453	259	351	550	449	242	289	293	329	7880

Number of species/0.2 Ha		160	131	134	161	188	221	211	145	107	103	136	142	86	76	108	84	802
#N/A	Dead saplings					2			1									3

Appendix 5. Seedling species composition in a four 1-ha plots in primary and logged lowland forests in the Bulungan Research Forest-CIFOR, East Kalimantan.

Family	Species Name	PF	LF-5	LF-10	LF-30	Total
Acanthaceae	*Acanthaceae 1*				192	192
	Acanthaceae 2				5	5
	Achanthus sp.	4	55			59
	Pseuderanthemum sp			5		5
	Ptyssiglottis sp.	170		37		207
	Staurogyne sp.	3		2		5
	Thunbergia sp.			30		30
Actinidiaceae	*Saurauia sp.*	5	8	48	77	138
	Saurauia sp.1			23		23
Adiantceae	*Lindsaea scandens Hook.*			14		14
Alangiaceae	*Alangium javanicum (Blume) Wangerin*			3	3	6
	Alangium sp.			9	6	15
Amaryllidaceae	*Curculigo racemosa Ridl.*			53		53
	Curculigo sp.	1	22	134		157
Anacardiaceae	*Anacardiaceae*				40	40
	Anacardiaceae 1				1	1
	Bouea sp.		3			3
	Buchanania sessifolia Blume			1		1
	Buchanania sp.		38	1		39
	Calycarpacana sp.		1			1

	Campnosperma macrophylla		1			1
	Campnosperma sp.		6			6
	Dracontomelon dao Merrill & Rolfe		8	2		10
	Dracontomelon sp.			1		1
	Drimycarpus luridus (Hook.f.) Ding How	8			2	10
	Drimycarpus sp.			1	3	4
	Gluta macrocarpa (Engl.) Ding Hou	5			14	19
	Gluta sp.				4	4
	Gluta wallichii (Hook. f.) Ding Hou	60	377	47	91	575
	Koordersiodendron pinnatum Merrill				144	144
	Mangifera sp.		23	1		24
	Mangifera swintoniodes Kostermans	78			8	86
	Melanochyla sp.	1		1	13	15
	Melanochyla sp.1				6	6
	Melanochyla sp.2	12				12
	Parishia insignis Hook.f.				6	6
	Semecarpus sp.		130	10		140
	Swintonia sp.		16			16
Annonaceae	*Annonaceae*			1		1
	Artabotrys sp.	3	413	39	21	476
	Artabotrys sp.1			1		1
	Artabotrys suaveolens (Blume) Blume	9				9
	Cyathocalyx sp.		1			1
	Cyathostema excelsum J.Sinclair	20				20
	Dasymaschalon sp.			1		1
	Desmos chinensis Lour.	22				22
	Desmos sp.			3	3	6
	Fissistigma manubriatum (Hook.f. & Thomson) Merr.	10		1		11
	Fissistigma sp.				1	1
	Friesodielsia borneensis (Miq.) van Steenis	10		4		14
	Friesodielsia excisa (Miq.) van Steenis	8				8
	Friesodielsia sp.	10		29	44	83

Friesodielsia sp.1				2	2
Friesodielsia sp.2				1	1
Goniothalamus macrophyllus (Blume) Hook.f. & Thomson	1		9	3	13
Goniothalamus sp.	4	54	23	52	133
Goniothalamus sp.1	8		2	57	67
Goniothalamus sp.2	7				7
Mezzettia sp.		2	1	7	10
Miliusa sp.			6		6
Mitrelea sp.				10	10
Neo-uvaria				4	4
Neo-uvaria acuminatissima (Miq.) Airy Shaw	2				2
Polyalthia cauliflora Hook.f. & Thoms.	76		2	85	163
Polyalthia lateriflora King	5	18	15	137	175
Polyalthia microtus Miq.			1		1
Polyalthia rumphii Merrill	5		4	3	12
Polyalthia sp.	7	70	50	49	176
Polyalthia sp.1				3	3
Polyalthia sp.2	1				1
Polyalthia sumatrana (Miq.) Kurz	9	17	21	17	64
Polyalthia tomentosa	1				1
Popowia sp.		6	14	2	22
Pseudovaria sp.	1				1
Saccophetalum sp.		7	1		8
Sageraea sp.				21	21
Schindapsus sp.			198		198
Uvaria borneensis (Merr.) T.M.A.Utterige			4		4
Uvaria sp.	10	18	25	58	111
Uvaria sp.1				15	15
Uvaria sp.2				1	1
Uvaria sp.3				7	7
Uvaria sp.4				10	10
Xylopia elliptica Maingay ex Hook.f.			5		5

	Xylopia malayana Hook.f. & Thoms.	8				8
	Xylopia sp.		4	1		5
	Xylopia sp. 1		13		8	21
Apocynaceae	*Alstonia scholaris*		4			4
	Alstonia sp.	1	5	3	5	14
	Apocynaceae		1			1
	kibatalia		1			1
	Tabernaemontana macrocarpa Korth. Ex Blume			3		3
	Tabernaemontana pauciflora Wight			2		2
	Tabernaemontana sp.			1	1	2
	Willughbeia coriacea Wall.	58		33		91
	Willughbeia firma	15				15
	Willughbeia sp.	19				19
	Willughbeia sp.1	22			207	229
	Willughbeia sp.2	32			39	71
	Willughbeia sp.3				26	26
	Willughbeia sp.4	4				4
Araceae	*Aglaonema sp.*			4		4
	Alocasia sp.	6	9	30	52	97
	Alocasia sp.1			11	11	22
	Alocasia sp.2	2				2
	Alocasia sp.3				5	5
	Amorphophallus sp.			7		7
	Amorphophallus sp.1			3	7	10
	Anadendrum sp.	67				67
	Araceae		3			3
	Araceae 1			1		1
	Homalomena cordata Schott			49		49
	Homalomena sp.		2	48		50
	Homalomena sp.1			65		65
	Photos sp.	3		8	6	17
	Photos sp.1	13				13
	Photos sp.2	1				1
	Photos sp.3	1				1

	Raphidophora sp.	3	12			15
	Scindapsus sp.	12	209	214	101	536
	Scindapsus sp.1				4	4
	Scindapsus sp.2				5	5
Areliaceae	*Schefflera sp.*				1	1
Aristolochiaceae	*Thottea muluensis Ding Hou*	37		2		39
	Aristolochia sp.			8		8
	Thottea sp.			14	3	17
	Thottea sp.1	1				1
Arucariaceae	*Agathis bornensis Warb.*		1			1
Asclepiadaceae	*Hoya sp.*	1				1
	Thottea temosa (Blume) Ding Hou	55				55
Aspidaceae	*Dryopteris linearis*		15			15
	Dryopteris sp.	5				5
	Heterogonium sp.			26		26
	Tectaria sp.			25		25
	Tectaria sp.1			10		10
Aspleniaceae	*Asplenium nitens*		3	3		6
	Asplenium sp.		3	4		7
Athyriaceae	*Athyrium sp.*			10		10
	Diplazium sp.			35		35
	Diplazium sp.1			2		2
Begoniaceae	*Begonia sp.*	29			24	53
	Begonia sp.1				1	1
	Begonia sp.2				3	3
Blechnaceae	*Blechnum orientale L*		83	2		85
	Blechnum sp.			7		7
	Stenochlaena sp.			20		20
Bombacaceae	*Coelostegia sp.*			1		1
	Durio acutifolius (Mast.) Kosterm.	1	2			3
	Durio cuntleyensis		2			2
	Durio dulcis Becc.	14		1	10	25
	Durio griffithii Bakh.	1			2	3
	Durio kutejensis Becc.			2		2
	Durio lanceolatus Mast.	9			3	12

	Durio oxleyanus Griff.	1				1
	Durio sp.	2	3		3	8
	Durio sp.1		13			13
	Neesia sp.		9			9
	Neesia synandra Mast.				1	1
Burseraceae	*Canarium littorale Blume*		3			3
	Canarium megalanthum Merrill	1				1
	Canarium odonthophyllum Bakh.			4		4
	Canarium sp.		10	5	8	23
	Canarium sp.1				4	4
	Canarium sp.2				1	1
	Canarium sp.3				1	1
	Dacryodes incurvata (Engl.) H. J. Lam	17			15	32
	Dacryodes laxa (A. W. Benn.) H. J. Lam				1	1
	Dacryodes rostrata (Blume) H. J. Lam forma pubescens	7	447	48	30	532
	Dacryodes rugosa (Blume) H.J. Lam	44		17	95	156
	Dacryodes sp.	1	6	2	12	21
	Santiria griffithii Engl.	2	128	8	2	140
	Santiria sp.			11		11
	Santiria sp.1				68	68
	Triomma malaccensis Hook. f.	1				1
Capparaceae	*Capparis sp.*	3	3			6
Caprifoliaceae	*Viburnum sp.*	1		1		2
Celasaceae	*Celastrus sp.*	1				1
Celastraceae	*Bhesa paniculata Arn.*		3	3		6
	Euonymus sp.	3				3
	Lophopetalum beccarianum Pierre	3			1	4
	Lophopetalum javanicum Turcz.	127			38	165
	Lophopetalum sp.		26	1	622	649
	Lophopetalum sp.1				2	2
	Salacia leucoclada Ridl.	3				3
	Salacia sp.	1		33	39	73
Combretaceae	*Combretum nigrescens King*	1		31	11	43

	Combretum sp.	1			33	34
	Combretum sp.1				5	5
	Terminalia sp.			3		3
Commelinaceae	*Commelina sp.*	1	5	42		48
	Forrestia sp.	4		6	8	18
	Polila sp.				1	1
Connaracae	*Agelaea borneensis Merril*			63	7	70
	Agelaea trinervis Merrill	50	18	65	41	174
	Cnestis platantha Griff	4			1	5
	Cnestis sp.				15	15
	Connarus sp.	1	223	96		320
	Connarus semidecandrus Jack	412		21	1717	2150
	Connarus sp.1				60	60
	Connarus sp.2				1	1
	Rourea sp.	2				2
	Rourea sp.1	3				3
	Rouriopsis mimosoides	1				1
Convolvulaceae	*Erycibe glomerolata Blume*	58				58
	Erycibe sp.	33		21	35	89
	Erycibe sp.1	3			5	8
	Erycibe sp.2	4				4
	Erycibe sp.3				1	1
	Erycibe sp.4	3			22	25
	Merremia sp.			9		9
Cornaceae	*Ellipanthus tomentosus Kurz*	1		2	24	27
Crypteronaceae	*Crypteronia sp.*				1	1
Cucurbitaceae	*Cucurbitaceae*				12	12
	Trichosanthes sp.				1	1
Cyperaceae	*Cyperus sp.*		1	44		45
	Mapania cuspidata			10		10
	Mapania sp.	5	13	46	7	71
	Scleria sp.			1		1
Dilleniacea	*Tetracera indica Merril*		90	21		111
	Tetracera scandens (L.) Merr.	19				19
	Tetracera sp.		7	58	92	157

	Tetracera sp.1	76				76
	Tetracera sp.2				6	6
Dilleniaceae	*Dillenia excelsa Martelli*	1	13	20	3	37
	Dillenia exima		5			5
	Dillenia sp.		1		3	4
	Dillenia suffruticosa (Griff.) Martelli			4		4
Dioscoreaceae	*Dioscorea olata*		1			1
	Dioscorea sp.		2	2		4
Dipterocarpaceae	*Anishoptera sp.*		24	16		40
	Dipterocarpus crinitus Dyer		157			157
	Dipterocarpus lowii Hook. f.		12			12
	Dipterocarpus sp.		119		169	288
	Dipterocarpus sp.1				9	9
	Dipterocarpus sp.2				26	26
	Dryobalanops lanceolata Burck	1431		30	1	1462
	Hopea cf. rudiformis				1	1
	Hopea dryobalanoides Miq.	4294	6138	42	3344	13818
	Hopea sp.			9		9
	Macaranga bancana Muell. Arg.		2			2
	Macaranga gigantea Muell. Arg.		1			1
	Macaranga pruinosa Muell. Arg.		2			2
	Macaranga sp.		4			4
	Mallotus penangensis Muell. Arg.		23			23
	Mallotus sp.		110			110
	Parashorea malaanonan Merrill	97	157	43	88	385
	Parashorea sp.		4	16	235	255
	Parashorea sp.1	1				1
	Parashorea tomentella (Symington) Meijer	51				51
	Shorea agamii P. S. Ashton				82	82
	Shorea angustifolia P. S. Ashton	993			472	1465
	Shorea beccarii Dyer ex Brandis	68			170	238
	Shorea cf. exstipulata	3				3
	Shorea cf. mujogensis P.S.Ashton	1112			748	1860
	Shorea cf. ovalis Blume				1	1

	Shorea cf. venulosa			57		57
	Shorea exstipulata	13				13
	Shorea fallax Meijer		36			36
	Shorea hopeifolia (Heim) Symington			69		69
	Shorea inappendiculata Burck			16		16
	Shorea johorensis Foxworthy	161	100	3	10	274
	Shorea laevifolia(Parijs) Endert		7			7
	Shorea leprosula Miq.	3	113	19	169	304
	Shorea macrophylla (de Vriese) P. S. Ashton		10	1	7	18
	Shorea macroptera Dyer	358	85		99	542
	Shorea maxwelliana King	17			157	174
	Shorea multiflora (Burck) Symington		192	170		362
	Shorea ovalis Blume	1	25		34	60
	Shorea parvifolia Dyer	1550	784	247	144	2725
	Shorea parvistipulata Heim	28		1	1	30
	Shorea patoienfis P. S. Ashton			5	1044	1049
	Shorea pauciflora King	146		2	6	154
	Shorea peltata Symington	171			33	204
	Shorea pinanga Scheff.		18	11		29
	Shorea sp.		22	11	5	38
	Shorea sp.1	29	1408	10	818	2265
	Shorea sp.2		76		2	78
	Vatica granulata v. Slooten	230				230
	Vatica micrantha v. Slooten	532			2808	3340
	Vatica nitens King	12				12
	Vatica oblongifolia Hook.f.			4		4
	Vatica sp.			26		26
	Vatica umbonata Burck	124		1	6	131
Ebenaceae	*Diospyros borneensis Hiern*	43			6	49
	Diospyros buxifolia Hiern	15	26	8	21	70
	Diospyros currannii Merr.	9				9
	Diospyros sp.	31	112	123	145	411
	Diospyros sp. 4				15	15
	Diospyros sp.1	5		1	11	17

	Diospyros sp.2	3		22	4	29
	Diospyros sp.3				1	1
	Diospyros sp.5				10	10
	Diospyros sumatrana Miq.	36		13	7	56
Elaeocarpaceae	*Elaeocarpus sp.*		14	1	1	16
	Elaeocarpus stipularis Blume				1	1
	Sloanea sp.				13	13
Ericaceae	*Ericaceae*			1		1
Euphorbiaceae	*Antidesma montanum Blume*	23				23
	Antidesma neurocarpum Miq.	41		6	1	48
	Antidesma sp.	1	35	5	21	62
	Antidesma sp.1			7	41	48
	Antidesma sp.2			1	3	4
	Antidesma sp.3				8	8
	Antidesma sp.4				1	1
	Antidesma tetandra		3			3
	Antidesma tomentosum Blume	16				16
	Aporosa dioica (Roxb.) Muell.Arg.	11				11
	Aporosa falcifera Hook.f.			36		36
	Aporosa frutescens Blume	2				2
	Aporosa grandistipulata Merril	1		3		4
	Aporosa lucida (Miq.) Airy Shaw	14				14
	Aporosa nitida Merrill	16		31	4	51
	Aporosa sp.	2	152	33	14	201
	Aporosa sp.1				10	10
	Aporosa subcaudata Merrill	54		5	7	66
	Baccaurea cf. tetandra	1				1
	Baccaurea kunstleri King ex Gage	1				1
	Baccaurea lanceolata (Miq) Muell.Arg.	10				10
	Baccaurea macrocarpa Muell. Arg.	5				5
	Baccaurea ornatus				1	1
	Baccaurea parviflora (Mull.Arg.) Mull.Arg.			2		2
	Baccaurea sp.	1	154	23	9	187

Baccaurea sp. 1	1				1
Baccaurea sumatrana Muell. Arg.	13				13
Baccaurea tetandra Muell. Arg.	187		11	1	199
Blumeodendron kurzii		1			1
Blumeodendron sp.	3	2	2	1	8
Blumeodendron tokbrai Kurz	3				3
Breynia sp.			5	3	8
Bridellia sp.		1			1
Cephalomappa beccariana Baill.				1	1
cf. Cleistantus				2	2
Chaetocarpus castanocarpus			1		1
Chaetocarpus sp.				1	1
Cleistanthus erycibifolius Airy Shaw	1				1
Cleistanthus myrianthus (Hassk.) Kurz	5			7	12
Cleistanthus sp.			6	40	46
Cleistanthus sp.1			11	5	16
Cleistanthus sp.2			4		4
Cleistanthus sp.3				3	3
Coccoceras sp.		24			24
Croton argyratus		94			94
Croton argyratus Blume	1			1	2
Croton sp.			5	13	18
Dimorphocalyx muricatus (Hook.f.) Airy Shaw	15				15
Dipterocarpus cornutus Dyer				2	2
Dipterocarpus eurynchus Miq.	215				215
Dipterocarpus sp.			9	28	37
Dipterocarpus sp.1				65	65
Dipterocarpus stellatus Vesque	24				24
Dipterocarpus verrucosus Foxworthy ex. v. Slooten	1				1
Drypetes kikir Airy Shaw	8			43	51
Drypetes longifolia (Blume) Pax & K.Hoffm>			8		8
Drypetes sp.	2	149	7	64	222

Drypetes sp.1				2	2
Elateriospermum sp.	1				1
Elateriospermum tapos Blume	3	3	429	510	945
Endospermum diadenum (Miq.) Airy Shaw			1		1
Euphorbiaceae (1)		7			7
Galearia fulpa			1		1
Galearia sp.			3		3
Glochidion sericeum			1		1
Glochidion sp.		10	12	5	27
Glochidion sp.1				1	1
Koilodepas brevipes Merr.	751		137	821	1709
Koilodepas sp.		482	106		588
Macaranga bancana Muell. Arg.	1	15	36	5	57
Macaranga beccariana Merrill		2	10		12
Macaranga hypoleuca Muell. Arg.			3		3
Macaranga lowii King ex Hook.f.	64			72	136
Macaranga pearsonii Merrill			5		5
Macaranga repando-dentata Airy Shaw			1		1
Macaranga sp.			50		50
Macaranga sp.1				5	5
Mallotus cf. griffithianus				603	603
Mallotus dispar (Blume) Mull.Arg.			59	291	350
Mallotus eucaustus Airy Shaw				12	12
Mallotus penangensis Muell.Arg.	27	3	37	26	93
Mallotus sp.	53	15	1		69
Mallotus sp.1	26				26
Mallotus wrayi King ex Hook. f.	98				98
Neoscortechinia	2				2
Neoscortechinia kingii Pax & K. Hoffm.	5				5
Omphalea bracteata (Blanco) Merr.			15	111	126
Paracroton pendulus Miq.			9	16	25
Paracroton sp.				13	13

	Pimeleodendron sp.		6			6
	Pimelodendron griffithianum (Muell. Arg.) Hook. f.			1	95	96
	Ptychopyxis bacciformis Croiz	3				3
	Ptycophxis sp.		19	14	214	247
	Trigonostemon elmeri Merr.	4				4
	Trigonostemon sp.	1			5	6
	Trigonostemon sp.1	7				7
	Trigonostemon sumatranus Pax & K.Hoffm.	20				20
	Trigonostemon villosus Hook.f.	26				26
Fagaceae	*Castanopsis sp.*	2			1	3
	Lithocarpus sp.	3	16	15	18	52
	Lithocarpus cooperta Rehder	2				2
	Quercus sp.	1				1
	Casearia sp.	1			10	11
Flacortiaceae	*Flacourtia rukam Zoll. & Mor.*		3	1	2	6
	Flacourtia sp.		1	2		3
	Hydnocarpus polypetalus (v.Slooten) Sleum.	4		2	2	8
	Hydnocarpus sp.	4	10	3	13	30
	Hydnocarpus sp.1	20		12		32
	Hydnocarpus sp.2	4				4
	Hydnocarpus sp.3	4				4
	Hydnocarpus sp.4				2	2
	Hydnocarpus woodii Merr.		5	14		19
	Osmelia sp.	1				1
	Ryparosa kostermansii Sleum.	11				11
	Ryparosa sp.			1	1	2
Flagelariacea	*Flagellaria sp.*				2	2
Gesneriaceae	*Aechynanthus sp.*	2				2
	Cyrtandra sp.	8	28	226	57	319
	Cyrtandra sp.1	12		6	2	20
	Cyrtandra sp.2	6		56		62
	Cyrtandra sp.3			5		5

	Cyrtandra sp.4			1		1
	Cyrtandra sp.5	1				1
	Cyrtandra sp.6	1				1
	Cyrtandra sp.7				1	1
Glicheniaceae	*Gleicheria linearis*		147			147
Gnetaceae	*Gnetum sp.*	2	5	5	122	134
Graminae	*Graminae*			2		2
	Leptasis sp.		4	16		20
	Scrotochloa urceolata (Roxb.) Judz.			24		24
Guttiferae	*Calophyllum gracilipes Merr.*	6				6
	Calophyllum pulcherimum		19			19
	Calophyllum sp.	3	146	66	61	276
	Calophyllum sp.1	1				1
	Calophyllum sp.2				1	1
	Garcinia bancana (Miq.) Miq.	7				7
	Garcinia nervosa Miq.	1			2	3
	Garcinia parvifolia Miq.	13				13
	Garcinia sp.	15	16	9	56	96
	Garcinia sp.1	2				2
	Kayea borneensis P. F. Stevens			5	1	6
	Kayea sp.		2	1		3
	Mammea sp.	4				4
	Mesua sp.	1		4	8	13
Hymenophyllaceae	*Tricomanes javanicum Blume*	12				12
Hypericaceae	*Cratoxylon formosum Benth. & Hook. F. ex Dyer*		12			12
	Cratoxylon sp.		4			4
	Cratoxylum orborescens				1	1
	Cratoxylum sp.				1	1
Icacinaceae	*Gonocaryum calleryanum (Baill.) Becc.*	3				3
	Gonocaryum sp.			7	2	9
	Maesa sp.				33	33
	Phytocrene sp.	12				12
	Phytocrene sp.1	1				1

	Stemonurus scorpioides Becc.	5				5
	Stemonurus scundiflorus		12			12
	Stemonurus sp.	3	1		96	100
	Stemonurus sp.1				1	1
	Icacinaceae				27	27
Juglandaceae	*Engelhardia serrata Blume*	6				6
Lauraceae	*Actinodaphne glabra Blume*			6	2	8
	Actinodaphne sp.		13	11	19	43
	Actinodaphne sp.1				1	1
	Actinodaphne sp.2				3	3
	Alseodaphne elmeri Merrill	6				6
	Alseodaphne sp.	2	5	36	82	125
	Beilschmiedia sp.	4				4
	Cinnamomum javanicum Blume	3	13			16
	Cinnamomum sp.		12	2		14
	Cryptocarya crassinervia Miq.	3				3
	Cryptocarya sp.		62	9	21	92
	Dehaasia sp.		30	3		33
	Endiandra kingiana Gamble	15				15
	Endiandra sp.	2			3	5
	Eusideroxylon zwageri Teijsm. & Binn.		2	36	16	54
	Lauraceae				5	5
	Litsea ferruginea			1		1
	Litsea firma Hook. F.	11			6	17
	Litsea oppositifolia L.S. Gibbs	8		1	3	12
	Litsea sp.	10	123	36	134	303
	Litsea sp.1				2	2
	Litsea sp.2				2	2
	Neolitsea sp.		32			32
Lecythidaceae	*Barringtonia macrostachya Kurz*	3				3
	Barringtonia sp.		3	1	4	8
	Planchonia sp.				1	1
Leeaceae	*Leea indica (Burm.f.) Merr.*	7	12	13	1	33
	Leea sp.			9		9
Leguminosae	*Abarema sp.*		1			1

Abrus sp.		40	3		43
Archidendron clypearia (Jack) I.C.Nielsen	4				4
Archidendron microcarpum (Bentham) I. Nielsen	3				3
Archidendron sp.		1	2		3
Archidendron sp.1				1	1
Bauhinia kockiana Korth.	30				30
Bauhinia semibifida Roxb.	14				14
Bauhinia sp.	1		167	53	221
Bouchinia sp.		70			70
Caesalpinia sp.	2	11	3		16
Cynometra ramiflora Miq.	4		21	27	52
Cynometra sp.		2	4		6
Dalbergia parviflora Roxb.	24				24
Dalbergia sp.	105	28	3	65	201
Dialium indum Linn	3				3
Dialium kunstleri Prain				136	136
Dialium platysepalum Baker			5	7	12
Dialium sp.	15	61	6	20	102
Fordia seclendia		2	3		5
Fordia sp.				1	1
Fordia splendidissima (Blume ex Miq.) J. R. M. Buijsen	22		65		87
Koompassia excelsa Taub.		5	20		25
Koompassia malaccensis Maing.	20	11	18	40	89
Koompassia sp.			3		3
Mucuna sp.				4	4
Parkia sp.				20	20
Parkia speciosa Hassk.		5	5	1	11
Parkia timoriana Merrill	2		1		3
Phanera sp.	2				2
Pithecellobium sp.		1			1
Saraca declinata Miq.	2			3	5
Saraca sp.		6			6

	Sindora leiocarpa Baker ex K.Heyne	9	4	6	2	21
	Sindora wallichii Benth		2	2	4	8
	Spatholobus ferrugineus Benth.	77		181	45	303
	Spatholobus hirsutus H.Wiriadinata & J.W.A.Ridder-Numan	36				36
	Spatholobus litoralis Hassk.	110		125		235
	Spatholobus macropterus Miq.	177				177
	Spatholobus sanguineus Elmer	116				116
	Spatholobus sp.	2		7	7	16
	Spatholobus sp.1	143			89	232
	Spatholobus sp.2	628			290	918
	Spatholobus sp.3	1			28	29
	Spatholobus sp.4				285	285
	Spatholobus sp.5	102				102
Liliaceae	*Dracaena sp.*	1		13	5	19
	Liliaceae		1			1
	Pleomele sp.		3	6		9
	Smilax sp.	7	5	7	1	20
	Smilax Zeylanica		8			8
Linaceae	*Indraroucrea sp.*			3		3
	Ixonanthus sp.		12			12
Loganiaceae	*Fagraea racemosa Jack ex Wall.*	1			3	4
	Fagraea sp.				3	3
	Fagraea sp.1				2	2
	Fragraea seroria		1			1
	Strychnos sp.	10		18	302	330
	Strychnos sp.1				1	1
Lycopodiaceae	*Lycopodium cernum*		14			14
	Lycopodium sp.	3				3
Magnoliaceae	*Elmerillia mollis*		2			2
	Magnolia candollii (Blume) H. P. Nooteboom	2			1	3
	Magnolia gigantifolia (Miq.) H. P. Nooteboom	1				1
	Magnolia lasia H. P. Noot.eboom			4	6	10

	Magnolia sp.	1	6	10	4	21
Maranthaceae	*Donax caniformis K.Schum*				41	41
	Phacelophrynium maximum			70		70
	Phrynium sp.	65	67	82	93	307
	Phrynium sp.1				1	1
	Phrynium sp.3				1	1
	Phrynium sp.4				1	1
	Phrynium sp.5				1	1
	Stachyphrynium borneensis			27		27
Melastomaceae	*Astronia sp.*	2				2
	Astronia sp.1	10				10
Melastomataceae	*Clidemia hirta D.Don*	1				1
	Clidemia sp.	1				1
	Medinella sp.		66	20		86
	Melastoma malabraticum		2			2
	Melastoma sp.		8	1		9
	Melastoma sp.1	24			1	25
	Memecylon borneense Merrill	4				4
	Memecylon edule Roxb.	7				7
	Memecylon sp.		87	6	4	97
	Pternandra azurea (Bl.) Burkill	1	3	8		12
	Pternandra caerulescens Jack		51	14		65
	Pternandra galeata Ridley	12				12
	Pternandra rostrata (Cogn.) M. P. Nayar				13	13
	Pternandra sp.	3	146	12	4	165
Meliaceae	*Aglaia argentea Blume*		1	4		5
	Aglaia simplicifolia Harms.	11			8	19
	Aglaia sp.	11	63	95	62	231
	Aglaia sp.1	2			7	9
	Aglaia sp.2	14			1	15
	Aglaia sp.3	1				1
	Aglaia sp.4	1				1
	Aglaia sp.5				3	3
	Aglaia tomentosa Teijsm. & Binn.	8	4	6		18

	Aglaia trinervis	25				25
	Chisocheton cf. patens	1				1
	Chisocheton sp.	2		2		4
	Dysoxylum alliaceum Blume	1				1
	Dysoxylum sp.		4	8	1	13
	Lansium domesticum Correa		3	4		7
	Lansium sp.				4	4
	Meliaceae 1				4	4
	Meliaceae 2				4	4
	Reinwardtiodendron humile (Hassk.) Mabb.	1				1
	Sandoricum sp.	3	1		9	13
	Walsura sp.	1		7	24	32
Menispermaceae	*Anamirta cocculus Wigght & Arn*			1		1
Menispermaceae	*Coscinium sp.*			1		1
	Fibraurea ochroleuca				50	50
	Fibraurea sp.				2	2
	Fibraurea tinctoria Lour.	8				8
	Menis sp.		17	17	11	45
	Menis sp.2				7	7
	Menisp. 1				17	17
	Stephania corymbosa			1		1
	Tinospora sp.			1		1
Moraceae	*Artocarpus cf. nitida*				1	1
	Artocarpus dadah Miq.	1			1	2
	Artocarpus elastica Reinw	1	4		12	17
	Artocarpus integer Merrill	7			12	19
	Artocarpus lanceifolius Roxb.	51	7	124	192	374
	Artocarpus sp.	2	17	3	49	71
	Artocarpus tamaran Becc.		1	4	1	6
	Ficus grossularioides Burm. f.			2	1	3
	Ficus obscura Blume		15	78	102	195
	Ficus sinuata Thunb	1				1
	Ficus sp.	1	76	88	23	188
	Ficus sp.1	11		51	1	63

	Ficus sp.2	1		1		2
	Ficus sp.3	1				1
	Ficus sp.4	1				1
	Ficus sp.5				1	1
	Moraceae 1				4	4
	Moraceae 2				27	27
	Parartocarpus sp.				7	7
	Prainea sp.			9	2	11
Musaceae	*Musa sp.*			21		21
Myristicaceae	*Gymnacranthera farquhariana Warb.*	1		2		3
	Gymnacranthera sp.		2	14	3	19
	Horsfieldia grandis Warb.				1	1
	Horsfieldia sp.		2	7	13	22
	Knema cinerea (Poir.) Warb.	10	58			68
	Knema furfuracea Warb.	48				48
	Knema glauca Warb.	14		37		51
	Knema glaucescens Jack	4				4
	Knema latericia Elmer	87		6	11	104
	Knema laurina Warb.	32				32
	Knema palens W. J. J. O. de Wilde	4				4
	Knema sp.		10	19	213	242
	Knema sp.1	2			1	3
	Knema sp.2	1				1
	Knema sp.3				2	2
	Knema sp.4				3	3
	Knema sp.5				3	3
	Myristica iners Blume	8	16	5		29
	Myristica maxima Warb.				2	2
	Myristica simiarum A.DC.	2				2
	Myristica sp.		31	22	3	56
	Myristica villosa Warb.	2				2
Myrsinaceae	*Ardisia cf. lanceolata*	1				1
	Ardisia korthalsiana Scheff.	2				2
	Ardisia lanceolata	4				4
	Ardisia megistosepala Merr.	7				7

	Ardisia sp.	27	36	39	16	118
	Ardisia sp.1	9		2		11
	Embelia sp.	2		1		3
	Labisia pumila (Blume) Benth. & Hook.f.	16		22		38
Myrtacaceae	*cf. Syzygium*				1	1
	Eugenia caudatilimba Merr.	8				8
	Eugenia sp.			47		47
	Syzygium grande Wall.				2	2
	Syzygium horsfieldii	2				2
	Syzygium sp.	27	806	158	104	1095
	Syzygium sp.1	3			72	75
	Syzygium sp.2	1			1	2
	Syzygium sp.3	1				1
	Syzygium sp.4				70	70
	Syzygium sp.5				3	3
	Syzygium tawahense (Korth.) Merrill & Perry	113				113
	Tristaniopsis sp.		6			6
Nepenthaceae	*Nephentes melamphora*		8			8
Nephrolepydaceae	*Nephrolepis bisserrata*		1	2		3
	Nephrolepis sp.		90	13	3	106
Ochnaceae	*Gomphia serrata (Gaertn.) Kanis*	1				1
Olacaceae	*Ochanostachys amentacea Mast.*	1	1	3	3	8
	Strombosia sp.			1		1
Oleaceae	*Chionanthus sp.*	12	115	72	36	235
	Linociera macrophylla		1			1
	Linociera sp.			1		1
	Linociera sp.1		2			2
Orchidaceae	*Calanthe sp.*		7			7
	cf. Calanthe			26		26
	Dendrobium sp.		6			6
	Orchidaceae		23		1	24
	Spathoglottis sp.		193	49		242
Oxalidaceae	*Sarcotheca diversifolia (Miq..) Hallier*			4	12	16

	f.					
	Sarcotheca sp.		6			6
Palmae	*Arenga sp.*			7	2	9
	Artocarpus lanceifolia Roxb.				5	5
	Artocarpus sp.				2	2
	Calamus blumei Becc.	30	10	10		50
	Calamus caesius				8	8
	Calamus flabellatus Becc.	15			1	16
	Calamus javensis Blume	4		10		14
	Calamus sp.		172	74	66	312
	Calamus sp.1	3				3
	Calamus sp.2	7		1	1	9
	Calamus tiliaris		1			1
	Caryota sp.			5	10	15
	Ceratolobus sp.	1				1
	Daemonorops sabut Becc.	15	9	19	24	67
	Daemonorops sp.	18	330	116	95	559
	Korthalsia echinometra Becc.	6	53	26	56	141
	Korthalsia ferox Becc.	45			5	50
	Korthalsia furtadoana J.Dransf.	13			9	22
	Korthalsia sp.	2	69	51	17	139
	Korthalsia sp.1			7		7
	Korthalsia sp.2				2	2
	Licuala sp.		7	1	7	15
	Licuala spinosa Thunb.	3				3
	Pinanga sp.		1			1
	Salacca sp.				1	1
	Freycinetia sp.	9	21	2	3	35
	Pandanus sp.	4	200	63	13	280
	Pandanus sp.1			20	3	23
	Pandanus sp.2			26		26
	Pandanus sp.4				1	1
Passifloraceae	*Adenia macrophylla Blume Kord.*			1		1
Piperaceae	*Piper baccatum Blume*	1				1
	Piper sp.		71	40	6	117

	Piper sp.1				1	1
	Piper sp.2				1	1
Podocarpaceae	*Nageia wallichiana Kuntze*	1				1
Polygalaceae	*Xanthophyllum affine Korth. ex. Miq.*	33			24	57
	Xanthophyllum cf. griffithii Hook.f. ex Benn	44				44
	Xanthophyllum ellipticum Korth. ex Miq.	1				1
	Xanthophyllum flavescens	2				2
	Xanthophyllum griffithii Hook. f. ex A. W. Benn.				5	5
	Xanthophyllum heterophyllum			2		2
	Xanthophyllum heterophyllum Meijden		5			5
	Xanthophyllum obscurum A.W.Benn.			1		1
	Xanthophyllum rufum A.W. Benn.	23			6	29
	Xanthophyllum sp.	16	27	56	51	150
	Xanthophyllum sp.1	5		33	4	42
	Xanthophyllum sp.2			14		14
	Xanthophyllum sp.3			8		8
	Xanthophyllum sp.4				2	2
	Xanthophyllum sp.5				50	50
	Xanthophyllum sp.6	9				9
	Xanthophyllum sp.7				8	8
Polypodiaceae	*Dipteris conjungata Reinw.*	1				1
	Dipteris sp.	1				1
	Drynaria sparsisora (Desv.) Moore	6				6
	Fern sp.				3	3
	Fern sp.1		6			6
	Fern sp.2		114	53		167
	Fern sp.3		4	1		5
	Fern sp.4		29	10		39
	Fern sp.5		42	1		43
	Fern sp.6		39			39
	Fern sp.7		4			4
	Fern sp.8	1			26	27

	Fern sp.9				37	37
	Fern sp.10				2	2
	Fern sp.11				8	8
	Fern sp.12				6	6
	Fern sp.13			18		18
	Oleandra sp.(Vern)	1				1
Proteaceae	*Helicia sp.*	11	1	2	7	21
	Helicia sp.1				1	1
	Helicia sp.2				1	1
Rhamnaceae	*Rhamnaceae*	1				1
	Sageretia hamosa Brongn.	10				10
	Ventilago sp.	113	24	136	323	596
	Ziziphus angustifolia (Miq.) Hatusina ex Stesnis			8		8
	Ziziphus horsfieldii	1				1
	Ziziphus liana				1	1
	Ziziphus sp.		72	28	14	114
	Ziziphus sp.1			19	4	23
	Ziziphus sp.2			2		2
	Ziziphus sp.3				5	5
	Ziziphus sp.4				8	8
Rhizoporaceae	*Anisophyllea corneri Ding Hou*	3				3
	Anisophyllea disticha Baill.	7				7
	Carallia bracteata (Lour.) Merr.			1		1
	Carallia sp.				1	1
Rosaceae	*Prunus sp.*	2		2		4
	Rubus moluccana			1		1
	Licania splendens (Kortthal) Prance		1			1
	Parinari oblongifolia Hook. f.				2	2
	Parinari sp.		2		1	3
	Parinari sp.1				1	1
Rubiacea	*Acranthera sp.*	9				9
	Anthocephalus chinensis Walp.		1	3		4
	Argostemma sp.			79		79
	Canthium sp.	4				4

Cephaelis sp.	3				3
cf. Argostemma sp.			10		10
Frismatomeris beccariana (Baill.) Johans	6				6
Frismatomeris sp.			19		19
Gaertnera sp.				16	16
Gaertnera sp.1				124	124
Gardenia sp.	1	7	2	7	17
Hedyotis cf. congesta Wall. Ex G.Don			39		39
Hedyotis sp.	3				3
Hypobathrum sp.	8		9	13	30
Ixora cf. fumialis	19				19
Ixora javanica	13				13
Ixora sp.		59	16		75
Ixora sp.1	114			311	425
Ixora sp.2	6		1	1	8
Ixora sp.3	4			29	33
Kailarsenia sp.	1				1
Lasianthus angustifolia King & Gamble			11		11
Lasianthus sp.		162	81		243
Lasianthus sp.1	4				4
Lasianthus sp.2	3				3
Mussaenda sp.	11	45	45	11	112
Nauclea sp.	7	6	12	5	30
Oxyceros sp.			4		4
Paederia foetida L.	6				6
Pavetta sp.	14				14
Pleiocarpidia sp.			1		1
Porterandia anisophylla (Jack ex Roxb.) Ridley	3				3
Porterandia sp.				3	3
Praravinia sp.	1				1
Psychotria sarmentosa Blume	2				2
Psychotria sp.	3	1			4

Psychotria viridiflora Reinw.ex Blume	1				1
Psychotria viridis Ruiz & Paw	1				1
Rathmannia sp.	1				1
Rubiaceae		8	6		14
Rubiaceae 1				2	2
Rubiaceae 2				6	6
Rubiaceae 3			1		1
Rubiaceae 4				3	3
Rubiaceae 5	1		9	18	28
Saprosma membranocea Merr.			1		1
Steenisia sp.			8		8
Streblosa sp.			52		52
Tarenna sp.			3		3
Timonius flavescens (Jack) Baker	2				2
Timonius lasianthoides Valet.	2				2
Timonius sp.		47	6		53
Timonius sp.1			22	29	51
Timonius sp.2				2	2
Tricalysia sp.		69	9		78
Uncaria hirsuta	1				1
Uncaria hirta	1				1
Uncaria littorale	1				1
Uncaria longifolia (Poir.) Merr.			38		38
Uncaria sp.	1	24	19	11	55
Uncaria sp.1		3	3		6
Uncaria sp.2			13		13
Uncaria sp.3				1	1
Urophyllum arborescens	35				35
Urophyllum glabrum Jack ex wall	7				7
Urophyllum sp.	3		6	81	90
Urophyllum sp.1	36		23	1	60
Urophyllum sp.2	15		3	6	24
Urophyllum sp.3	1			7	8
Urophyllum sp.4				1	1
Urophyllum sp.5				3	3

	Urophyllum sp.6	11				11
Rutaceae	*Luvunga sp.*	10	24	46	170	250
	Luvunga sp.1	20				20
	Luvunga sp.2	1				1
	Rutaceae 1				1	1
	Rutaceae 2				4	4
Sabiaceae	*Meliosma integrifolia*		1			1
	Meliosma sp.		1	2		3
	Meliosma sumatrana (Jack) Walp.	1			5	6
Sapindaceae	*Dimocarpus dentatus W. Meijer ex Leenhouts*	22			48	70
	Dimocarpus longan Lour.			13		13
	Dimocarpus sp.		13	38		51
	Guioa sp.	2				2
	Lepisanthus fruticosa (Roxb.) Leenh.	3				3
	Lepisanthus sp.			1		1
	Mischocarpus sp.			5		5
	Nephelium cuspidatum Blume	3			1	4
	Nephelium lappaceum L.	1		1	1	3
	Nephelium sp.		34	34		68
	Nephelium uncinatum Radlk.	2	73	22	13	110
	Paranephelium nitidum King				3	3
	Pometia pinnata G.Forst.	4	8	74	11	97
	Xerospermum noronhianum Blume	4			1	5
	Xerospermum sp.	2			37	39
Sapotaceae	*Madhuca beccariana*				1	1
	Madhuca mindanaensis Merrill	15		15		30
	Madhuca pallida (Burck) Baehni	6				6
	Madhuca sp.	4			81	85
	Madhuca sp.1				2	2
	Madhuca sp.2	2				2
	Palaquium calophyllum Pierre ex Burck	5				5
	Palaquium gutta Burck		1			1
	Palaquium leiocarpum				22	22

	Palaquium obovatum		2			2
	Palaquium quercifolium Burck	3	15	8		26
	Palaquium rostratum Burck	10	1	20	67	98
	Palaquium sp.		43	1	16	60
	Palaquium stenophyllum H.J.Lam			54		54
	Payena sp.			1		1
	Pouteria sp		16			16
Schizaeaceae	*Lygodium cyrcinatum*			4	7	11
	Lygodium sp.		12	3		15
	Schizaea sp.	11				11
Selaginellaceae	*Selaginella*		24			24
	Selaginella plana		212			212
	Selaginella sp.			8	1	9
Simaraubaceae	*Eurycoma longifolia Jack*	5	4	1	6	16
Simaroubaceae	*Irvingia malayana Oliver*			1	5	6
Sterculiaceae	*Buettneria sp.*			2	1	3
	Heritiera elata Ridley	1				1
	Heritiera sp.		2			2
	Heritiera sumatrana (Miq.) Kosterm.	2			4	6
	Pterospermum javanicum Jungh.				1	1
	Scaphium macropodum Beume ex K. Heyne	177		23	1058	1258
	Scaphium sp.		3			3
	Sterculia rubiginosa Vent			10	7	17
	Sterculia sp.	1	7	8	31	47
	Sterculia sp.1	2		5	42	49
	Sterculia sp.2				1	1
	Sterculia sp.3				2	2
	Sterculiaceae	2				2
Symplocaceae	*Symplocos sp.*	1	7	3	22	33
	Symplocos sp.1				2	2
	Symplocos sp.2				5	5
Tectraria group	*Arcypteris irregularis*	1				1
	Tectraria sp.		1			1
Theaceae	*Adinandra sp.*	2	25	2		29

	Ternstroemia sp.		1			1
	Tetramerista glabra Miq.	1				1
	Tetramerista sp.		14			14
Theaeceae	*Camellia lanceolata Seem.*	1				1
Thelypteridaceae	*Pronephrium rubicundum*			8		8
Thymelaeaceae	*Aquilaria beccariana van Tiegh.*		1	2		3
	Aquilaria malaccensis Lam.	3			7	10
	Aquilaria sp.		1			1
	Enkleia malaccensis Griff.	9	1	2	48	60
	Enkleia sp.		9			9
	Gonystylus affine	1				1
	Gonystylus macrophyllus			1		1
	Gonystylus sp.				12	12
	Gonystylus velutinus Airy Shaw	1				1
Tiliaceae	*Brownlowia peltata Benth.*		41	35	15	91
	Grewia fibrocarpa Mast.	4				4
	Grewia paniculata		4			4
	Grewia sp.		7	1		8
	Microcos cinnamomifolia (Burret) Stapf ex P.S.Ashton	2				2
	Microcos crassifolia Burret	4		2	2	8
	Microcos sp.		2	2	3	7
	Microcos tomentosa Sm.	6		1	9	16
	Pentace adenophora Kosterm.	1			2	3
	Pentace erectinervia Kosterm.			2		2
	Pentace laxiflora Merr.			8		8
	Pentace sp.	5		6	5	16
	Pentace sp.1	47				47
Trigoniaceae	*Trigoniastrum hypoleucum Miq.*	3				3
	Trigoniastrum sp.	7			3	10
	Trigoniastrum sp.1	1				1
	Trigoniastrum sp.2	5				5
Ulmaceae	*Gironniera nervosa Plancoh.*			9	2	11
	Gironniera subaequalis Planch.		10			10
Urticaceae	*Dendrocnide sp.*	7		14	4	25

	Laportea sp.			1		1
	Orophea sp.		2			2
	Poikilospermum sp.			2	4	6
	Urticaceae		11	206		217
Verbenaceae	*Callicarpa longifolia Lam.*			11		11
	Callicarpa sp.	7			7	14
	Clerodendron sp.			5	2	7
	Geunsia pentandra Merr.			2		2
	Geunsia sp.			1		1
	Teijsmanniodendron sp.	16	49	7	43	115
	Teijsmanniodendron bogoriense Koord.				7	7
	Teijsmanniodendron sp.1				2	2
	Vitex sp.			6		6
Vitaceae	*Ampelocissus Borneensis*	2				2
	Ampelocissus imperialis			1	6	7
	Ampelocissus sp.	13				13
	Cayratia sp.				2	2
	Cayratia sp.1	77				77
	Cayratia sp.2	1				1
	Cissus sp.	2		5		7
	Pterisanthes sp.			6		6
	Pterisanthes sp.1				1	1
	Tetrastigma manubriatum				5	5
	Tetrastigma sp.	1	7	12	7	27
	Tetrastigma sp.1				1	1
	Vitaceae sp.				1	1
	Vitaceae sp.1				1	1
	Vitis sp.		6	4		10
Zingiberaceae	*Alpinia aquatica Rosc.*	25				25
	Alpinia galanga Willd.	24				24
	Alpinia ligulata			34		34
	Alpinia sp.	13	87	416	68	584
	Alpinia sp.1	4				4
	Amomum sp.		11	34		45

	Costus globosus			310		310
	Costus sp.		245	198	8	451
	Costus speciosus (Koenig) Smith			1		1
	Etlingera littoralis			27		27
	Etlingera sp.		5	70		75
	Globba sp.	37	86	109	27	259
	Globba sp.1	5				5
	Hornstedtia sp.				12	12
	Hornstedtia sp.1				17	17
	Hornstedtia sp.2				2	2
	Plagiostachys cf. breviramosa			21		21
	Plagiostachys sp.			231		231
	Zingiber sp.			8	5	13
	Zingiber sp.1		118	137	19	274
	Zingiber sp.2		4	1	3	8
	Zingiber sp.3		435	1		436
	Zingiber sp.4		11	1		12
	Zingiber sp.5		56	1		57
	Zingiber sp.6			1		1
	Zingiber sp.7			1		1
	Zingiber sp.8			1		1
	Zingiber sp.9			1		1
	Zingiber sp. 10			273		273
	Zingiber sp.11				1	1
	Zingiber sp.12			1		1
NA	*Indet*	1		40	2	43
	Indet 1				46	46
	Indet 2				3	3
	Indet 3				2	2
	Indet 4				2	2
	Indet 5				2	2
	Indet 6				2	2
	Indet 7				1	1
	Indet 8				7	7

Number of seedlings/0.05 ha	19416	20256	11158	26351	77181
Number of species/0.05 ha	469	295	451	489	1022

Appendix 6. Seedling species composition in 1-ha plot in primary and logged lowland forests in the Bulungan Research Forest-CIFOR, East Kalimantan.

Family	Species Name	PF				LF-5				LF-10				LF-30				Total
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Acanthaceae	*Acanthaceae 1*													17	85	82	8	192
	Acanthaceae 2													1	4			5
	Achanthus sp.				4				55									59
	Pseuderanthemum sp									5								5
	Ptyssiglottis sp.		170							26	11							207
	Staurogyne sp.				3						2							5
	Thunbergia sp.									23	7							30
Actinidiaceae	*Saurauia sp.*		2		3		2		6	30	10	6	2		57	20		138
	Saurauia sp.1									1	22							23
Adiantceae	*Lindsaea scandens Hook.*										14							14
Alangiaceae	*Alangium javanicum (Blume) Wangerin*											3		1		2		6
	Alangium sp.									2	7			2	1	2	1	15
Amaryllidaceae	*Curculigo racemosa Ridl.*									32	21							53
	Curculigo sp.				1	7	8	3	4			130	4					157
Anacardiaceae	*Anacardiaceae*													3			37	40
	Anacardiaceae 1													1				1
	Bouea sp.					1		2										3
	Buchanania sessifolia Blume										1							1
	Buchanania sp.					9	2	10	17		1							39

	Calycarpacana sp.								1									1
	Campnosperma macrophylla					1												1
	Campnosperma sp.						2	1	3									6
	Dracontomelon dao Merrill & Rolfe					5			3		1	1						10
	Dracontomelon sp.												1					1
	Drimycarpus luridus (Hook.f.) Ding How	1	3	2	2									1		1		10
	Drimycarpus sp.										1						3	4
	Gluta macrocarpa (Engl.) Ding Hou			3	2											9	5	19
	Gluta sp.													3		1		4
	Gluta wallichii (Hook. f.) Ding Hou	13	9	29	9	76	6	281	14	3	31	13		18	1	72		575
	Koordersiodendron pinnatum Merrill													2	14	109	19	144
	Mangifera sp.						5	18				1						24
	Mangifera swintoniodes Kostermans	3	11	42	22									6	2			86
	Melanochyla sp.				1					1				1	1	1	10	15
	Melanochyla sp.1														3	3		6
	Melanochyla sp.2		12															12
	Parishia insignis Hook.f.													3		1	2	6
	Semecarpus sp.					26	15	71	18	1	2	2	5					140
	Swintonia sp.					3	3	1	9									16
Annonaceae	*Annonaceae*										1							1
	Artabotrys sp.				3	176	51	91	95		2	27	10	5		13	3	476
	Artabotrys sp.1										1							1
	Artabotrys suaveolens (Blume) Blume	4		2	3													9
	Cyathocalyx sp.					1												1
	Cyathostema excelsum J.Sinclair	10	4	4	2													20
	Dasymaschalon sp.									1								1
	Desmos chinensis Lour.	6	6	3	7													22

Desmos sp.										3						3	6
Fissistigma manubriatum (Hook.f. & Thomson) Merr.	1	2	3	4						1							11
Fissistigma sp.															1		1
Friesodielsia borneensis (Miq.) van Steenis	10								3	1							14
Friesodielsia excisa (Miq.) van Steenis			8														8
Friesodielsia sp.				10					3	26			12	13	5	14	83
Friesodielsia sp.1													1	1			2
Friesodielsia sp.2															1		1
Goniothalamus macrophyllus (Blume) Hook.f. & Thomson				1					7	2			1			2	13
Goniothalamus sp.				4	2	6	23	23	10	6	3	4	5	24	17	6	133
Goniothalamus sp.1		3		5						2				56	1		67
Goniothalamus sp.2	2	5															7
Mezzettia sp.					1			1			1				7		10
Miliusa sp.										6							6
Mitrelea sp.														10			10
Neo-uvaria														4			4
Neo-uvaria acuminatissima (Miq.) Airy Shaw	1		1														2
Polyalthia cauliflora Hook.f. & Thoms.	12	31	17	16					2				28	24	22	11	163
Polyalthia lateriflora King	1	1		3	6	1		11	5		5	5	117	14	4	2	175
Polyalthia microtus Miq.										1							1
Polyalthia rumphii Merrill	2	2	1							4			2		1		12
Polyalthia sp.				7	27	15	18	10	9	21	19	1	12	14	7	16	176
Polyalthia sp.1														3			3
Polyalthia sp.2				1													1
Polyalthia sumatrana (Miq.) Kurz	5	2		2	11	4	2		3	4	7	7	8	1	4	4	64
Polyalthia tomentosa				1													1

	Popowia sp.					1			5		3	8	3			1	1	22
	Pseudovaria sp.				1													1
	Saccophetalum sp.					4	1		2			1						8
	Sageraea sp.													20			1	21
	Schindapsus sp.									92	106							198
	Uvaria borneensis (Merr.) T.M.A.Utterige									3	1							4
	Uvaria sp.				10	10		4	4	9	7	8	1	12	6	1	39	111
	Uvaria sp.1															15		15
	Uvaria sp.2															1		1
	Uvaria sp.3													2			5	7
	Uvaria sp.4													1	6	3		10
	Xylopia elliptica Maingay ex Hook.f.									2	3							5
	Xylopia malayana Hook.f. & Thoms.	6		2														8
	Xylopia sp.					2	2					1						5
	Xylopia sp. 1							3	10					1		3	4	21
Apocynaceae	*Alstonia scholaris*					3	1											4
	Alstonia sp.		1					2	3	1		2				1	4	14
	Apocynaceae								1									1
	kibatalia					1												1
	Tabernaemontana macrocarpa Korth. Ex Blume									3								3
	Tabernaemontana pauciflora Wight									1	1							2
	Tabernaemontana sp.									1					1			2
	Willughbeia coriacea Wall.	12	10	28	8					13	20							91
	Willughbeia firma				15													15
	Willughbeia sp.				19													19
	Willughbeia sp.1	13			9									114		53	40	229
	Willughbeia sp.2	14		13	5									5	4	14	16	71
	Willughbeia sp.3													17	6	3		26
	Willughbeia sp.4				4													4

Araceae	*Aglaonema sp.*									4								4
	Alocasia sp.		5	1			1	4	4	8	5	3	14	2	29	17	4	97
	Alocasia sp.1									11					10	1		22
	Alocasia sp.2			2														2
	Alocasia sp.3															2	3	5
	Amorphophallus sp.									1	6							7
	Amorphophallus sp.1											3			4		3	10
	Anadendrum sp.	11	35	5	16													67
	Araceae					3												3
	Araceae 1									1								1
	Homalomena cordata Schott									39	10							49
	Homalomena sp.					1	1			37		8	3					50
	Homalomena sp.1									57	8							65
	Photos sp.				3						8			1		2	3	17
	Photos sp.1	4	4	5														13
	Photos sp.2			1														1
	Photos sp.3	1																1
	Raphidophora sp.		2		1		3	7	2									15
	Scindapsus sp.				12	16	46	48	99			42	172	15	24	18	44	536
	Scindapsus sp.1														4			4
	Scindapsus sp.2													3	2			5
Areliaceae	*Schefflera sp.*													1				1
Aristolochiaceae	*Thottea muluensis Ding Hou*	3	3	20	11						2							39
	Aristolochia sp.									8								8
	Thottea sp.										14			1		2		17
	Thottea sp.1		1															1
Arucariaceae	*Agathis bornensis Warb.*							1										1
Asclepiadaceae	*Hoya sp.*	1																1
	Thottea temosa (Blume) Ding Hou				55													55
Aspidaceae	*Dryopteris linearis*					15												15
	Dryopteris sp.	2	2		1													5
	Heterogonium sp.									26								26
	Tectaria sp.									19	6							25

	Tectaria sp.1									2	8							10
Aspleniaceae	*Asplenium nitens*					1	1	1					3					6
	Asplenium sp.						1	1	1	1	3							7
Athyriaceae	*Athyrium sp.*										10							10
	Diplazium sp.									35								35
	Diplazium sp.1									2								2
Begoniaceae	*Begonia sp.*		29											1		22	1	53
	Begonia sp.1														1			1
	Begonia sp.2															3		3
Blechnaceae	*Blechnum orientale L*					65			18			2						85
	Blechnum sp.									1	6							7
	Stenochlaena sp.										20							20
Bombacaceae	*Coelostegia sp.*									1								1
	Durio acutifolius (Mast.) Kosterm.				1		2											3
	Durio cuntleyensis					2												2
	Durio dulcis Becc.	1		6	7					1				1	1	7	1	25
	Durio griffithii Bakh.				1												2	3
	Durio kutejensis Becc.											2						2
	Durio lanceolatus Mast.				9											3		12
	Durio oxleyanus Griff.				1													1
	Durio sp.			2		1	2							2		1		8
	Durio sp.1							2	11									13
	Neesia sp.					1	4		4									9
	Neesia synandra Mast.													1				1
Burseraceae	*Canarium littorale Blume*					2			1									3
	Canarium megalanthum Merrill	1																1
	Canarium odonthophyllum Bakh.									2	2							4
	Canarium sp.					1	1	6	2		1	3	1	2	3	2	1	23
	Canarium sp.1														4			4
	Canarium sp.2														1			1
	Canarium sp.3															1		1

	Dacryodes incurvata (Engl.) H. J. Lam				17										12	3		32
	Dacryodes laxa (A. W. Benn.) H. J. Lam														1			1
	Dacryodes rostrata (Blume) H. J. Lam forma pubescens	6		1		39	14	31	363	4	18	16	10	6	16	5	3	532
	Dacryodes rugosa (Blume) H.J. Lam	12	5	16	11					11	6			21	1	44	29	156
	Dacryodes sp.				1				6	1	1			3		5	4	21
	Santiria griffithii Engl.	2				1		1	126		4	4				1	1	140
	Santiria sp.									8	3							11
	Santiria sp.1													63	1	2	2	68
	Triomma malaccensis Hook. f.				1													1
Capparaceae	*Capparis sp.*			3			3											6
Caprifoliaceae	*Viburnum sp.*				1							1						2
Celasaceae	*Celastrus sp.*			1														1
Celastraceae	*Bhesa paniculata Arn.*					2			1		3							6
	Euonymus sp.	1			2													3
	Lophopetalum beccarianum Pierre				3									1				4
	Lophopetalum javanicum Turcz.			127										38				165
	Lophopetalum sp.					6	13	2	5			1		93		120	409	649
	Lophopetalum sp.1													2				2
	Salacia leucoclada Ridl.	1		2														3
	Salacia sp.				1					11	22			27	7	3	2	73
Combretaceae	*Combretum nigrescens King*	1								28	3				11			43
	Combretum sp.				1									8	13	10	2	34
	Combretum sp.1														5			5
	Terminalia sp.											3						3
Commelinaceae	*Commelina sp.*				1	2	2		1	27	9	2	4					48
	Forrestia sp.		4							5	1			2	1	4	1	18
	Polila sp.														1			1
Connaracae	*Agelaea borneensis Merril*									22	41				5	2		70

	Agelaea trinervis Merrill	27	1	5	17	10	4	4		46	18		1	15	15	9	2	174
	Cnestis platantha Griff				4									1				5
	Cnestis sp.													4	1	4	6	15
	Connarus sp.			1		43	34	20	126	6	41	27	22					320
	Connarus semidecandrus Jack	100	143	102	67					3	18			805	89	176	647	2150
	Connarus sp.1													25	4		31	60
	Connarus sp.2														1			1
	Rourea sp.	2																2
	Rourea sp.1	2	1															3
	Rouriopsis mimosoides				1													1
Convolvulaceae	*Erycibe glomerolata Blume*	43	9	4	2													58
	Erycibe sp.				33					8	13			13	7	4	11	89
	Erycibe sp.1	3														2	3	8
	Erycibe sp.2	4																4
	Erycibe sp.3															1		1
	Erycibe sp.4				3									5		14	3	25
	Merremia sp.									4	4		1					9
Cornaceae	*Ellipanthus tomentosus Kurz*	1									2			5		5	14	27
Crypteronaceae	*Crypteronia sp.*																1	1
Cucurbitaceae	*Cucurbitaceae*													1	10	1		12
	Trichosanthes sp.														1			1
Cyperaceae	*Cyperus sp.*							1				44						45
	Mapania cuspidata									1	9							10
	Mapania sp.		5			5		7	1	6	1	39			5	2		71
	Scleria sp.									1								1
Dilleniacea	*Tetracera indica Merril*					21	14	39	16			7	14					111
	Tetracera scandens (L.) Merr.	11	2		6													19
	Tetracera sp.					1	5		1	2	25	29	2	4	10	7	71	157
	Tetracera sp.1			75	1													76
	Tetracera sp.2															6		6
Dilleniaceae	*Dillenia excelsa Martelli*		1						13	2	16	2		2		1		37
	Dillenia exima					5												5

	Dillenia sp.					1									1	2		4
	Dillenia suffruticosa (Griff.) Martelli										4							4
Dioscoreaceae	*Dioscorea olata*					1												1
	Dioscorea sp.						1		1	2								4
Dipterocarpaceae	*Anishoptera sp.*					1	2		21			4	12					40
	Dipterocarpus crinitus Dyer					117		28	12									157
	Dipterocarpus lowii Hook. f.					6		5	1									12
	Dipterocarpus sp.					116		3						6		9	154	288
	Dipterocarpus sp.1													7	2			9
	Dipterocarpus sp.2														5	8	13	26
	Dryobalanops lanceolata Burck		1431								1	27	2			1		1462
	Hopea cf. rudiformis														1			1
	Hopea dryobalanoides Miq.	1247	880	2167		1259	3707	1166	6	2	2	37	1	1087	41	775	1441	13818
	Hopea sp.									7		2						9
	Macaranga bancana Muell. Arg.								2									2
	Macaranga gigantea Muell. Arg.								1									1
	Macaranga pruinosa Muell. Arg.								2									2
	Macaranga sp.							2	2									4
	Mallotus penangensis Muell. Arg.							23										23
	Mallotus sp.							100	10									110
	Parashorea malaanonan Merrill	7	14		76	1	49		107	20	20	1	2	8	33	47		385
	Parashorea sp.								4	16				9	120	103	3	255
	Parashorea sp.1				1													1
	Parashorea tomentella (Symington) Meijer		47	4														51
	Shorea agamii P. S. Ashton													72			10	82
	Shorea angustifolia P. S. Ashton	80	223	2	688									461		7	4	1465
	Shorea beccarii Dyer ex	1	14	28	25									34	9	123	4	238

Brandis																	
Shorea cf. exstipulata				3													3
Shorea cf. mujogensis P.S.Ashton		1112											748				1860
Shorea cf. ovalis Blume													1				1
Shorea cf. venulosa									1	56							57
Shorea exstipulata				13													13
Shorea fallax Meijer						3		33									36
Shorea hopeifolia (Heim) Symington										69							69
Shorea inappendiculata Burck									15	1							16
Shorea johorensis Foxworthy	60	3	97	1	11	51	19	19			3		1	1	6	2	274
Shorea laevifolia(Parijs) Endert					1		6										7
Shorea leprosula Miq.	3						106	7	17			2		95	74		304
Shorea macrophylla (de Vriese) P. S. Ashton						7	3					1				7	18
Shorea macroptera Dyer	37	3	180	138	21		64						5	1	1	92	542
Shorea maxwelliana King				17											1	156	174
Shorea multiflora (Burck) Symington					89	65	38		124	40	6						362
Shorea ovalis Blume		1			14			11						2	30	2	60
Shorea parvifolia Dyer	312	142	77	1019	68	41	41	634	5	12	5	225	3	128		13	2725
Shorea parvistipulata Heim	12			16					1					1			30
Shorea patoienfis P. S. Ashton									5				32	155	128	729	1049
Shorea pauciflora King	23	10	12	101					2							6	154
Shorea peltata Symington			171										6	22		5	204
Shorea pinanga Scheff.					3	1	14		5			6					29
Shorea sp.					21			1			1	10	2	2		1	38
Shorea sp.1				29				1408				10	766		52		2265
Shorea sp.2						52	24						2				78
Vatica granulata v. Slooten	38	183	9														230
Vatica micrantha v. Slooten				532											1122	1686	3340

	Vatica nitens King		12															12
	Vatica oblongifolia Hook.f.										4							4
	Vatica sp.												26					26
	Vatica umbonata Burck	61	41	13	9					1				5		1		131
Ebenaceae	*Diospyros borneensis Hiern*	1	30	10	2									4			2	49
	Diospyros buxifolia Hiern		12	2	1	18	8					7	1	3	2	16		70
	Diospyros currannii Merr.		5	4														9
	Diospyros sp.	4			27	7	15	23	67	52	34	20	17	27	45	28	45	411
	Diospyros sp. 4													3	12			15
	Diospyros sp.1			2	3						1			3			8	17
	Diospyros sp.2				3					8	14			1	3			29
	Diospyros sp.3													1				1
	Diospyros sp.5													5		2	3	10
	Diospyros sumatrana Miq.	5	24	3	4					6	7			3	2	1	1	56
Elaeocarpaceae	*Elaeocarpus sp.*					3	2	9					1	1				16
	Elaeocarpus stipularis Blume													1				1
	Sloanea sp.													1	1	10	1	13
Ericaceae	*Ericaceae*										1							1
Euphorbiaceae	*Antidesma montanum Blume*	3	1	9	10													23
	Antidesma neurocarpum Miq.	10	9		22						6					1		48
	Antidesma sp.				1	1	13	13	8	1	1	3		4		11	6	62
	Antidesma sp.1									5	2			6	9	7	19	48
	Antidesma sp.2									1						3		4
	Antidesma sp.3													1	5		2	8
	Antidesma sp.4															1		1
	Antidesma tetandra						3											3
	Antidesma tomentosum Blume		8	2	6													16
	Aporosa dioica (Roxb.) Muell.Arg.			11														11
	Aporosa falcifera Hook.f.									4	32							36
	Aporosa frutescens Blume		2															2
	Aporosa grandistipulata				1					1	2							4

Merril																	
Aporosa lucida (Miq.) Airy Shaw	10			4													14
Aporosa nitida Merrill	3	11	2						3	28			1		2	1	51
Aporosa sp.				2	50	16	59	27	3	8	19	3	2	4	5	3	201
Aporosa sp.1														6	2	2	10
Aporosa subcaudata Merrill	30	1	8	15						5			1	6			66
Baccaurea cf. tetandra				1													1
Baccaurea kunstleri King ex Gage				1													1
Baccaurea lanceolata (Miq) Muell.Arg.	4		4	2													10
Baccaurea macrocarpa Muell. Arg.	3		2														5
Baccaurea ornatus														1			1
Baccaurea parviflora (Mull.Arg.) Mull.Arg.									2								2
Baccaurea sp.				1	37	33	28	56		16	5	2	3	1	3	2	187
Baccaurea sp. 1				1													1
Baccaurea sumatrana Muell. Arg.	1	10	1	1													13
Baccaurea tetandra Muell. Arg.	16	4	162	5					9	2						1	199
Blumeodendron kurzii						1											1
Blumeodendron sp.				3			1	1	2							1	8
Blumeodendron tokbrai Kurz	2			1													3
Breynia sp.									2	1	1	1			3		8
Bridellia sp.						1											1
Cephalomappa beccariana Baill.													1				1
cf. Cleistantus														2			2
Chaetocarpus castanocarpus										1							1
Chaetocarpus sp.														1			1
Cleistanthus erycibifolius Airy Shaw	1																1

Cleistanthus myrianthus (Hassk.) Kurz	3			2									4	3			12
Cleistanthus sp.									5	1			18	18	2	2	46
Cleistanthus sp.1									10	1				5			16
Cleistanthus sp.2										4							4
Cleistanthus sp.3														3			3
Coccoceras sp.					11	9	3	1									24
Croton argyratus					93	1											94
Croton argyratus Blume		1													1		2
Croton sp.										5			2	1	8	2	18
Dimorphocalyx muricatus (Hook.f.) Airy Shaw		14	1														15
Dipterocarpus cornutus Dyer															1	1	2
Dipterocarpus eurynchus Miq.	1	81	1	132													215
Dipterocarpus sp.												9	25	3			37
Dipterocarpus sp.1													65				65
Dipterocarpus stellatus Vesque	4		9	11													24
Dipterocarpus verrucosus Foxworthy ex. v. Slooten	1																1
Drypetes kikir Airy Shaw	3		1	4											2	41	51
Drypetes longifolia (Blume) Pax & K.Hoffm>									8								8
Drypetes sp.	1			1	103	11	10	25		4	1	2	11	1	12	40	222
Drypetes sp.1															1	1	2
Elateriospermum sp.				1													1
Elateriospermum tapos Blume	2	1			1			2	46	235	142	6	509			1	945
Endospermum diadenum (Miq.) Airy Shaw										1							1
Euphorbiaceae (1)						7											7
Galearia fulpa										1							1
Galearia sp.									2	1							3

Glochidion sericeum									1								1
Glochidion sp.					1	1	2	6	3	5	3	1			3	2	27
Glochidion sp.1														1			1
Koilodepas brevipes Merr.	290	94	218	149					79	58			307	99	248	167	1709
Koilodepas sp.					185	114	41	142			102	4					588
Macaranga bancana Muell. Arg.		1			11	4			14	12	9	1	2		2	1	57
Macaranga beccariana Merrill					2				2	8							12
Macaranga hypoleuca Muell. Arg.											2	1					3
Macaranga lowii King ex Hook.f.	25			39											11	61	136
Macaranga pearsonii Merrill										5							5
Macaranga repando-dentata Airy Shaw									1								1
Macaranga sp.									3	4	9	34					50
Macaranga sp.1															5		5
Mallotus cf. griffithianus													240		300	63	603
Mallotus dispar (Blume) Mull.Arg.									30	29				291			350
Mallotus eucaustus Airy Shaw													3	4	5		12
Mallotus penangensis Muell.Arg.	12			15	3				11	12	5	9	15	7	4		93
Mallotus sp.				53	12	3					1						69
Mallotus sp.1				26													26
Mallotus wrayi King ex Hook. f.	10	1	77	10													98
Neoscortechinia				2													2
Neoscortechinia kingii Pax & K. Hoffm.	1			4													5
Omphalea bracteata (Blanco) Merr.									15				37	30	32	12	126
Paracroton pendulus Miq.										9			3	9	1	3	25
Paracroton sp.														13			13

	Pimeleodendron sp.					6												6
	Pimelodendron griffithianum (Muell. Arg.) Hook. f.										1			54	1	28	12	96
	Ptychopyxis bacciformis Croiz				3													3
	Ptycophxis sp.					15	2		2	9	5			43	145	12	14	247
	Trigonostemon elmeri Merr.	4																4
	Trigonostemon sp.				1										1	2	2	6
	Trigonostemon sp.1				7													7
	Trigonostemon sumatranus Pax & K.Hoffm.	19	1															20
	Trigonostemon villosus Hook.f.	26																26
Fagaceae	*Castanopsis sp.*		1		1												1	3
	Lithocarpus sp.				3	4	4	3	5	2	9	3	1	5	4	3	6	52
	Lithocarpus cooperta Rehder	2																2
	Quercus sp.		1															1
	Casearia sp.			1										2	3	1	4	11
Flacortiaceae	*Flacourtia rukam Zoll. & Mor.*					1			2	1						2		6
	Flacourtia sp.								1			2						3
	Hydnocarpus polypetalus (v.Slooten) Sleum.		1	3						2					2			8
	Hydnocarpus sp.				4	3		6	1		1		2		10		3	30
	Hydnocarpus sp.1				20					12								32
	Hydnocarpus sp.2				4													4
	Hydnocarpus sp.3				4													4
	Hydnocarpus sp.4														2			2
	Hydnocarpus woodii Merr.					5				11	3							19
	Osmelia sp.			1														1
	Ryparosa kostermansii Sleum.	1		5	5													11
	Ryparosa sp.										1			1				2
Flagelariacea	*Flagellaria sp.*															2		2
Gesneriaceae	*Aechynanthus sp.*		2															2

	Cyrtandra sp.				8		2	9	17	162	2	12	50		26	26	5	319
	Cyrtandra sp.1	3	3	3	3					6					2			20
	Cyrtandra sp.2		3		3					56								62
	Cyrtandra sp.3									5								5
	Cyrtandra sp.4										1							1
	Cyrtandra sp.5				1													1
	Cyrtandra sp.6				1													1
	Cyrtandra sp.7														1			1
Glicheniaceae	*Gleicheria linearis*					147												147
Gnetaceae	*Gnetum sp.*				2	2	1	1	1			5		8	1	26	87	134
Graminae	*Graminae*									2								2
	Leptasis sp.						4				2		14					20
	Scrotochloa urceolata (Roxb.) Judz.										24							24
Guttiferae	*Calophyllum gracilipes Merr.*	3	1	2														6
	Calophyllum pulcherimum						19											19
	Calophyllum sp.				3	9	18	110	9	11	30	24	1	32	6	20	3	276
	Calophyllum sp.1		1															1
	Calophyllum sp.2													1				1
	Garcinia bancana (Miq.) Miq.	1	4	2														7
	Garcinia nervosa Miq.	1														1	1	3
	Garcinia parvifolia Miq.	7	2	3	1													13
	Garcinia sp.	1		1	13	6	4	4	2	2	3	3	1	17	2	24	13	96
	Garcinia sp.1				2													2
	Kayea borneensis P. F. Stevens									2	3				1			6
	Kayea sp.								2				1					3
	Mammea sp.	1	3															4
	Mesua sp.				1						3	1		2		3	3	13
Hymenophyllaceae	*Tricomanes javanicum Blume*				12													12
Hypericaceae	*Cratoxylon formosum Benth. & Hook. F. ex Dyer*								12									12

	Cratoxylon sp.								4									4
	Cratoxylum orborescens															1		1
	Cratoxylum sp.																1	1
Icacinaceae	*Gonocaryum calleryanum (Baill.) Becc.*			3														3
	Gonocaryum sp.									4	3					1	1	9
	Maesa sp.														32	1		33
	Phytocrene sp.	10	1		1													12
	Phytocrene sp.1				1													1
	Stemonurus scorpioides Becc.	1	2	2														5
	Stemonurus scundiflorus					7		3	2									12
	Stemonurus sp.				3		1							28	5	11	52	100
	Stemonurus sp.1														1			1
	Icacinaceae													12	2	12	1	27
Juglandaceae	*Engelhardia serrata Blume*			6														6
Lauraceae	*Actinodaphne glabra Blume*									4	1	1			2			8
	Actinodaphne sp.					3	2	8		4		4	3	1	17	1		43
	Actinodaphne sp.1														1			1
	Actinodaphne sp.2														3			3
	Alseodaphne elmeri Merrill	4	1		1													6
	Alseodaphne sp.				2		1		4	20	11	5		36	6	21	19	125
	Beilschmiedia sp.			1	3													4
	Cinnamomum javanicum Blume	1		2		12		1										16
	Cinnamomum sp.							12			2							14
	Cryptocarya crassinervia Miq.	1	1		1													3
	Cryptocarya sp.					46	1	13	2		1	4	4	10	2	6	3	92
	Dehaasia sp.					29		1				2	1					33
	Endiandra kingiana Gamble	11	1	3														15
	Endiandra sp.				2										2	1		5
	Eusideroxylon zwageri Teijsm. & Binn.						2			16	5	12	3	3	3	5	5	54
	Lauraceae													1		4		5

	Litsea ferruginea											1						1
	Litsea firma Hook. F.	5		4	2										5		1	17
	Litsea oppositifolia L.S. Gibbs	5	3							1					1	1	1	12
	Litsea sp.		1	5	4	65	10	31	17	5	15	15	1	39	15	11	69	303
	Litsea sp.1													2				2
	Litsea sp.2													2				2
	Neolitsea sp.					10		21	1									32
Lecythidaceae	*Barringtonia macrostachya Kurz*	3																3
	Barringtonia sp.					2		1			1				1		3	8
	Planchonia sp.															1		1
Leeaceae	*Leea indica (Burm.f.) Merr.*		5	2		1	2	1	8	5		2	6		1			33
	Leea sp.									2	7							9
Leguminosae	*Abarema sp.*							1										1
	Abrus sp.					12	6	8	14			1	2					43
	Archidendron clypearia (Jack) I.C.Nielsen	1		3														4
	Archidendron microcarpum (Bentham) I. Nielsen	1		2														3
	Archidendron sp.								1	1	1							3
	Archidendron sp.1													1				1
	Bauhinia kockiana Korth.	11	8	10	1													30
	Bauhinia semibifida Roxb.		14															14
	Bauhinia sp.				1					43	47	33	44	12	7	34		221
	Bouchinia sp.					1	1	55	13									70
	Caesalpinia sp.				2	5	1		5			1	2					16
	Cynometra ramiflora Miq.	1	3							11	10			1	19	7		52
	Cynometra sp.								2			3	1					6
	Dalbergia parviflora Roxb.	10	7	3	4													24
	Dalbergia sp.				105	2	1	24	1	2	1			10	5	22	28	201
	Dialium indum Linn		1	2														3
	Dialium kunstleri Prain													3	111	22		136
	Dialium platysepalum Baker									1	4			5	1	1		12

Dialium sp.				15	3	3	12	43			5	1	1	17	2		102
Fordia seclendia					2							3					5
Fordia sp.														1			1
Fordia splendidissima (Blume ex Miq.) J. R. M. Buijsen		22							10	55							87
Koompassia excelsa Taub.								5	10	4	5	1					25
Koompassia malaccensis Maing.	1	3		16	3	3	1	4	2	13	1	2	11	1	16	12	89
Koompassia sp.											3						3
Mucuna sp.														4			4
Parkia sp.													7	13			20
Parkia speciosa Hassk.								5				5	1				11
Parkia timoriana Merrill		1	1						1								3
Phanera sp.				2													2
Pithecellobium sp.								1									1
Saraca declinata Miq.		2												3			5
Saraca sp.					5		1										6
Sindora leiocarpa Baker ex K.Heyne	1		2	6	3	1				1	5			1		1	21
Sindora wallichii Benth						2			2					3	1		8
Spatholobus ferrugineus Benth.				77					104	77			1	22	19	3	303
Spatholobus hirsutus H.Wiriadinata & J.W.A.Ridder-Numan	33	2		1													36
Spatholobus litoralis Hassk.				110					14	111							235
Spatholobus macropterus Miq.	19	16	127	15													177
Spatholobus sanguineus Elmer		116															116
Spatholobus sp.				2					7					5	1	1	16
Spatholobus sp.1	12	14	14	103									4	1	80	4	232
Spatholobus sp.2	230			398									148	7	66	69	918
Spatholobus sp.3	1												9		11	8	29
Spatholobus sp.4													68	152		65	285

	Spatholobus sp.5				102													102
Liliaceae	*Dracaena sp.*				1					9	2		2	4			1	19
	Liliaceae						1											1
	Pleomele sp.					3						6						9
	Smilax sp.				7			5		1	2		4	1				20
	Smilax Zeylanica					5	2	1										8
Linaceae	*Indraroucrea sp.*									3								3
	Ixonanthus sp.					3	3	6										12
Loganiaceae	*Fagraea racemosa Jack ex Wall.*		1													3		4
	Fagraea sp.														1		2	3
	Fagraea sp.1																2	2
	Fragraea seroria							1										1
	Strychnos sp.	2	4		4					8	10			113	9	81	99	330
	Strychnos sp.1													1				1
Lycopodiaceae	*Lycopodium cernum*					14												14
	Lycopodium sp.		2		1													3
Magnoliaceae	*Elmerillia mollis*					1	1											2
	Magnolia candollii (Blume) H. P. Nooteboom	1		1												1		3
	Magnolia gigantifolia (Miq.) H. P. Nooteboom				1													1
	Magnolia lasia H. P. Noot.eboom									2	2			1	2	1	2	10
	Magnolia sp.				1	1	3	2		5	2	1	2		2		2	21
Maranthaceae	*Donax caniformis K.Schum*														25	13	3	41
	Phacelophrynium maximum									27	43							70
	Phrynium sp.	54	9	1	1	20		23	24			50	32	1	42		50	307
	Phrynium sp.1														1			1
	Phrynium sp.3																1	1
	Phrynium sp.4																1	1
	Phrynium sp.5														1			1
	Stachyphrynium borneensis									2	25							27
Melastomaceae	*Astronia sp.*			2														2

	Astronia sp.1			10														10
Melastomataceae	*Clidemia hirta D.Don*			1														1
	Clidemia sp.	1																1
	Medinella sp.					20	14	11	21	3	6	6	5					86
	Melastoma malabraticum						2											2
	Melastoma sp.					3	2	2	1			1						9
	Melastoma sp.1				24												1	25
	Memecylon borneense Merrill	4																4
	Memecylon edule Roxb.	1	2	4														7
	Memecylon sp.					23	8	54	2		2	2	2			4		97
	Pternandra azurea (Bl.) Burkill	1				3						8						12
	Pternandra caerulescens Jack						1	34	16			14						65
	Pternandra galeata Ridley			10	2													12
	Pternandra rostrata (Cogn.) M. P. Nayar															8	5	13
	Pternandra sp.				3	26	48	54	18	2	8		2			3	1	165
Meliaceae	*Aglaia argentea Blume*						1			3			1					5
	Aglaia simplicifolia Harms.	7		2	2									4	1	2	1	19
	Aglaia sp.				11	11	18	24	10	24	29	36	6	22	18	7	15	231
	Aglaia sp.1			2										7				9
	Aglaia sp.2		10	3	1									1				15
	Aglaia sp.3		1															1
	Aglaia sp.4				1													1
	Aglaia sp.5														3			3
	Aglaia tomentosa Teijsm. & Binn.	4	3	1		3		1				4	2					18
	Aglaia trinervis				25													25
	Chisocheton cf. patens				1													1
	Chisocheton sp.			1	1						2							4
	Dysoxylum alliaceum Blume		1															1
	Dysoxylum sp.						1		3	8				1				13
	Lansium domesticum Correa								3			2	2					7

	Lansium sp.													4				4
	Meliaceae 1													1	3			4
	Meliaceae 2														2		2	4
	Reinwardtiodendron humile (Hassk.) Mabb.		1															1
	Sandoricum sp.				3				1					2	4		3	13
	Walsura sp.				1					7				11	10	3		32
Menispermaceae	*Anamirta cocculus Wigght & Arn*									1								1
Menispermaceae	*Coscinium sp.*										1							1
	Fibraurea ochroleuca													38		2	10	50
	Fibraurea sp.														2			2
	Fibraurea tinctoria Lour.	4		1	3													8
	Menis sp.					7		4	6			6	11		10		1	45
	Menis sp.2													3		1	3	7
	Menisp. 1														17			17
	Stephania corymbosa									1								1
	Tinospora sp.										1							1
Moraceae	*Artocarpus cf. nitida*																1	1
	Artocarpus dadah Miq.			1										1				2
	Artocarpus elastica Reinw		1						4					2	3	6	1	17
	Artocarpus integer Merrill	4	1	2										1		3	8	19
	Artocarpus lanceifolius Roxb.	2		40	9	2	1	4		44	66	13	1	130	17	33	12	374
	Artocarpus sp.				2	1		13	3	1		1	1	9	29	10	1	71
	Artocarpus tamaran Becc.							1		4					1			6
	Ficus grossularioides Burm. f.									2						1		3
	Ficus obscura Blume					3			12	57	3	13	5		69	32	1	195
	Ficus sinuata Thunb		1															1
	Ficus sp.				1	14	8	44	10	25	23	31	9	1	15	2	5	188
	Ficus sp.1		10	1						34	3	12	2		1			63
	Ficus sp.2			1							1							2
	Ficus sp.3		1															1
	Ficus sp.4			1														1

	Ficus sp.5													1				1
	Moraceae 1														4			4
	Moraceae 2														24	3		27
	Parartocarpus sp.													6		1		7
	Prainea sp.									9					1	1		11
Musaceae	*Musa sp.*									9	12							21
Myristicaceae	*Gymnacranthera farquhariana Warb.*	1								1	1							3
	Gymnacranthera sp.					2				1	13				2		1	19
	Horsfieldia grandis Warb.														1			1
	Horsfieldia sp.							1	1		7			3	2		8	22
	Knema cinerea (Poir.) Warb.				10	22	17	16	3									68
	Knema furfuracea Warb.	32	8	8														48
	Knema glauca Warb.	13		1						17	20							51
	Knema glaucescens Jack	1		3														4
	Knema latericia Elmer	81		1	5					5	1			1		6	4	104
	Knema laurina Warb.	14	2	8	8													32
	Knema palens W. J. J. O. de Wilde	1			3													4
	Knema sp.					4	3	3		4	11	3	1	50	39	25	99	242
	Knema sp.1				2									1				3
	Knema sp.2				1													1
	Knema sp.3													1		1		2
	Knema sp.4													1	1		1	3
	Knema sp.5													1	1		1	3
	Myristica iners Blume	1			7	15		1		1	1	3						29
	Myristica maxima Warb.														2			2
	Myristica simiarum A.DC.			2														2
	Myristica sp.					15	4	5	7			17	5	1	1	1		56
	Myristica villosa Warb.	1			1													2
Myrsinaceae	*Ardisia cf. lanceolata*				1													1
	Ardisia korthalsiana Scheff.	2																2
	Ardisia lanceolata				4													4
	Ardisia megistosepala Merr.	7																7

	Ardisia sp.	2	15	4	6	11	13	5	7	11	20	1	7		15	1		118
	Ardisia sp.1		9							2								11
	Embelia sp.			2						1								3
	Labisia pumila (Blume) Benth. & Hook.f.	15	1							22								38
Myrtacaceae	*cf. Syzygium*																1	1
	Eugenia caudatilimba Merr.	3		1	4													8
	Eugenia sp.											36	11					47
	Syzygium grande Wall.															2		2
	Syzygium horsfieldii				2													2
	Syzygium sp.	1		1	25	275	78	370	83	15	143			33	8	20	43	1095
	Syzygium sp.1			3										72				75
	Syzygium sp.2	1												1				2
	Syzygium sp.3				1													1
	Syzygium sp.4													59	11			70
	Syzygium sp.5																3	3
	Syzygium tawahense (Korth.) Merrill & Perry	13	62	24	14													113
	Tristaniopsis sp.							5	1									6
Nepenthaceae	*Nephentes melamphora*							8										8
Nephrolepydaceae	*Nephrolepis bisserrata*								1				2					3
	Nephrolepis sp.					2	85	3		10	1	1	1			3		106
Ochnaceae	*Gomphia serrata (Gaertn.) Kanis*			1														1
Olacaceae	*Ochanostachys amentacea Mast.*				1	1					3					1	2	8
	Strombosia sp.										1							1
Oleaceae	*Chionanthus sp.*	4	1	2	5	4	8	17	86	12	17	34	9	9		10	17	235
	Linociera macrophylla						1											1
	Linociera sp.											1						1
	Linociera sp.1						2											2
Orchidaceae	*Calanthe sp.*						5		2									7
	cf. Calanthe									23	3							26
	Dendrobium sp.							6										6

	Orchidaceae					6	1	16								1		24
	Spathoglottis sp.					29	28	3	133			23	26					242
Oxalidaceae	*Sarcotheca diversifolia (Miq..) Hallier f.*									1	3			3			9	16
	Sarcotheca sp.							5	1									6
Palmae	*Arenga sp.*									2	2	2	1		2			9
	Artocarpus lanceifolia Roxb.													5				5
	Artocarpus sp.													2				2
	Calamus blumei Becc.	2	24	4		8	2			1		7	2					50
	Calamus caesius														6	2		8
	Calamus flabellatus Becc.	11			4											1		16
	Calamus javensis Blume				4					1	9							14
	Calamus sp.					32	67	35	38	26	16	22	10	28	12		26	312
	Calamus sp.1				3													3
	Calamus sp.2	5		2						1						1		9
	Calamus tiliaris					1												1
	Caryota sp.									3	2			2		8		15
	Ceratolobus sp.				1													1
	Daemonorops sabut Becc.	2	9		4			9				3	16			24		67
	Daemonorops sp.		1	13	4	107	22	171	30	12	43	22	39	49	6	15	25	559
	Korthalsia echinometra Becc.		3		3	6	12	22	13	1	25			4	35		17	141
	Korthalsia ferox Becc.	20	14		11									1		3	1	50
	Korthalsia furtadoana J.Dransf.	10	3												9			22
	Korthalsia sp.		1		1	5	16		48	8	19	7	17	2		12	3	139
	Korthalsia sp.1										7							7
	Korthalsia sp.2													2				2
	Licuala sp.						6	1			1			2		1	4	15
	Licuala spinosa Thunb.	3																3
	Pinanga sp.							1										1
	Salacca sp.																1	1
	Freycinetia sp.				9			21		1			1	1	1		1	35
	Pandanus sp.	3			1	39	40	64	57			48	15	1	4	7	1	280

	Pandanus sp.1									1	19						3	23
	Pandanus sp.2									22	4							26
	Pandanus sp.4														1			1
Passifloraceae	*Adenia macrophylla Blume Kord.*									1								1
Piperaceae	*Piper baccatum Blume*				1													1
	Piper sp.					1	14	1	55	16	7	3	14		6			117
	Piper sp.1														1			1
	Piper sp.2															1		1
Podocarpaceae	*Nageia wallichiana Kuntze*				1													1
Polygalaceae	*Xanthophyllum affine Korth. ex. Miq.*	2	3	20	8									4	1	11	8	57
	Xanthophyllum cf. griffithii Hook.f. ex Benn	19	2	23														44
	Xanthophyllum ellipticum Korth. ex Miq.	1																1
	Xanthophyllum flavescens				2													2
	Xanthophyllum griffithii Hook. f. ex A. W. Benn.													2		2	1	5
	Xanthophyllum heterophyllum										2							2
	Xanthophyllum heterophyllum Meijden					1		2	2									5
	Xanthophyllum obscurum A.W.Benn.									1								1
	Xanthophyllum rufum A.W. Benn.			23										2			4	29
	Xanthophyllum sp.	2	2		12	14	2	11		6	5	25	20	15	16	14	6	150
	Xanthophyllum sp.1				5					18	15			1	3			42
	Xanthophyllum sp.2									4	10							14
	Xanthophyllum sp.3										8							8
	Xanthophyllum sp.4													2				2
	Xanthophyllum sp.5													1	1		48	50
	Xanthophyllum sp.6				9													9
	Xanthophyllum sp.7													8				8

Polypodiaceae	*Dipteris conjungata Reinw.*			1														1
	Dipteris sp.		1															1
	Drynaria sparsisora (Desv.) Moore	1	5															6
	Fern sp.													2			1	3
	Fern sp.1					6												6
	Fern sp.2					2	30	63	19			4	49					167
	Fern sp.3						4						1					5
	Fern sp.4							29				4	6					39
	Fern sp.5							42				1						43
	Fern sp.6						7	4	28									39
	Fern sp.7						4											4
	Fern sp.8				1									4	6	15	1	27
	Fern sp.9														1	36		37
	Fern sp.10															1	1	2
	Fern sp.11																8	8
	Fern sp.12													6				6
	Fern sp.13											18						18
	Oleandra sp.(Vern)		1															1
Proteaceae	*Helicia sp.*	1	3	2	5	1				2				6			1	21
	Helicia sp.1														1			1
	Helicia sp.2														1			1
Rhamnaceae	*Rhamnaceae*				1													1
	Sageretia hamosa Brongn.			4	6													10
	Ventilago sp.	9	71	10	23		1	17	6	47	82	5	2	97	34	176	16	596
	Ziziphus angustifolia (Miq.) Hatusina ex Stesnis									5	3							8
	Ziziphus horsfieldii				1													1
	Ziziphus liana														1			1
	Ziziphus sp.					25	25	14	8			10	18	3	1	8	2	114
	Ziziphus sp.1									10	9			3	1			23
	Ziziphus sp.2									2								2
	Ziziphus sp.3														5			5
	Ziziphus sp.4													3	4	1		8

Rhizoporaceae	*Anisophyllea corneri Ding Hou*		1	2														3
	Anisophyllea disticha Baill.	7																7
	Carallia bracteata (Lour.) Merr.										1							1
	Carallia sp.															1		1
Rosaceae	*Prunus sp.*				2						2							4
	Rubus moluccana									1								1
	Licania splendens (Kortthal) Prance					1												1
	Parinari oblongifolia Hook. f.															2		2
	Parinari sp.						1	1									1	3
	Parinari sp.1													1				1
Rubiacea	*Acranthera sp.*	3	5	1														9
	Anthocephalus chinensis Walp.								1	1		2						4
	Argostemma sp.									72	7							79
	Canthium sp.	3		1														4
	Cephaelis sp.	3																3
	cf. Argostemma sp.									10								10
	Frismatomeris beccariana (Baill.) Johans	1	2	2	1													6
	Frismatomeris sp.									8	11							19
	Gaertnera sp.														2	14		16
	Gaertnera sp.1														124			124
	Gardenia sp.			1			1	6		1	1			6			1	17
	Hedyotis cf. congesta Wall. Ex G.Don										39							39
	Hedyotis sp.	1	2															3
	Hypobathrum sp.		4	3	1						9			6	2	5		30
	Ixora cf. fumialis		19															19
	Ixora javanica				13													13
	Ixora sp.					14	45			5	11							75
	Ixora sp.1	28	13	6	67									145		160	6	425

Ixora sp.2	3		1	2						1					1		8
Ixora sp.3				4									14	3	1	11	33
Kailarsenia sp.		1															1
Lasianthus angustifolia King & Gamble									7	4							11
Lasianthus sp.					4	16	111	31	26	5	28	22					243
Lasianthus sp.1	1	3															4
Lasianthus sp.2			3														3
Mussaenda sp.				11	1	9	4	31	9	5	9	22	2	2	2	5	112
Nauclea sp.		7					3	3	3		1	8			1	4	30
Oxyceros sp.										4							4
Paederia foetida L.	3	3															6
Pavetta sp.	7	3	4														14
Pleiocarpidia sp.										1							1
Porterandia anisophylla (Jack ex Roxb.) Ridley				3													3
Porterandia sp.															2	1	3
Praravinia sp.		1															1
Psychotria sarmentosa Blume				2													2
Psychotria sp.	2	1				1											4
Psychotria viridiflora Reinw.ex Blume				1													1
Psychotria viridis Ruiz & Paw	1																1
Rathmannia sp.				1													1
Rubiaceae					6	2			5	1							14
Rubiaceae 1															2		2
Rubiaceae 2														1		5	6
Rubiaceae 3											1						1
Rubiaceae 4																3	3
Rubiaceae 5				1							1	8	1	7	1	9	28
Saprosma membranocea Merr.										1							1
Steenisia sp.										8							8

	Streblosa sp.									52								52
	Tarenna sp.										3							3
	Timonius flavescens (Jack) Baker	1		1														2
	Timonius lasianthoides Valet.	1		1														2
	Timonius sp.					16	12	2	17	2	4							53
	Timonius sp.1											22			1	26	2	51
	Timonius sp.2															2		2
	Tricalysia sp.					1	10	25	33			9						78
	Uncaria hirsuta				1													1
	Uncaria hirta				1													1
	Uncaria littorale				1													1
	Uncaria longifolia (Poir.) Merr.									12	26							38
	Uncaria sp.				1		1		23		3		16	4	2	2	3	55
	Uncaria sp.1								3	2	1							6
	Uncaria sp.2											13						13
	Uncaria sp.3																1	1
	Urophyllum arborescens	11	14	10														35
	Urophyllum glabrum Jack ex wall				7													7
	Urophyllum sp.				3					2	4			21	18	10	32	90
	Urophyllum sp.1				36					19	4			1				60
	Urophyllum sp.2				15					3				5		1		24
	Urophyllum sp.3				1									3		4		8
	Urophyllum sp.4													1				1
	Urophyllum sp.5															3		3
	Urophyllum sp.6				11													11
Rutaceae	*Luvunga sp.*				10	2	3	9	10	6	24	15	1	29	11	40	90	250
	Luvunga sp.1	11	1	8														20
	Luvunga sp.2	1																1
	Rutaceae 1														1			1
	Rutaceae 2														4			4
Sabiaceae	*Meliosma integrifolia*								1									1

	Meliosma sp.					1						1	1					3
	Meliosma sumatrana (Jack) Walp.				1										3		2	6
Sapindaceae	*Dimocarpus dentatus W. Meijer ex Leenhouts*	11		10	1									6	6	22	14	70
	Dimocarpus longan Lour.									12	1							13
	Dimocarpus sp.					2	6		5			9	29					51
	Guioa sp.		2															2
	Lepisanthus fruticosa (Roxb.) Leenh.			2	1													3
	Lepisanthus sp.									1								1
	Mischocarpus sp.									2	3							5
	Nephelium cuspidatum Blume				3									1				4
	Nephelium lappaceum L.			1						1				1				3
	Nephelium sp.					2	5	3	24	2	10	4	18					68
	Nephelium uncinatum Radlk.				2	2	23	46	2			12	10	7		5	1	110
	Paranephelium nitidum King														3			3
	Pometia pinnata G.Forst.	4				4		1	3	71	2		1			10	1	97
	Xerospermum noronhianum Blume			3	1									1				5
	Xerospermum sp.				2									8	15	5	9	39
Sapotaceae	*Madhuca beccariana*														1			1
	Madhuca mindanaensis Merrill	1	13	1						4	11							30
	Madhuca pallida (Burck) Baehni	4	1	1														6
	Madhuca sp.				4									36	7	32	6	85
	Madhuca sp.1															2		2
	Madhuca sp.2				2													2
	Palaquium calophyllum Pierre ex Burck	2	3															5
	Palaquium gutta Burck								1									1
	Palaquium leiocarpum													8	7	7		22
	Palaquium obovatum					2												2

	Palaquium quercifolium Burck				3	2			13			7	1					26
	Palaquium rostratum Burck			9	1				1	3	17			4	4	9	50	98
	Palaquium sp.					1		41	1				1		4	2	10	60
	Palaquium stenophyllum H.J.Lam									39	15							54
	Payena sp.										1							1
	Pouteria sp					16												16
Schizaeaceae	*Lygodium cyrcinatum*									3	1				4	3		11
	Lygodium sp.								12				3					15
	Schizaea sp.		4		7													11
Selaginellaceae	*Selaginella*					2	22											24
	Selaginella plana						112	82	18									212
	Selaginella sp.									5			3			1		9
Simaraubaceae	*Eurycoma longifolia Jack*	5					1	3			1			3			3	16
Simaroubaceae	*Irvingia malayana Oliver*										1			1		3	1	6
Sterculiaceae	*Buettneria sp.*										2					1		3
	Heritiera elata Ridley			1														1
	Heritiera sp.							1	1									2
	Heritiera sumatrana (Miq.) Kosterm.	1			1									1		3		6
	Pterospermum javanicum Jungh.																1	1
	Scaphium macropodum Beume ex K. Heyne	40	13	59	65					7	5	11		81	34	445	498	1258
	Scaphium sp.						2		1									3
	Sterculia rubiginosa Vent									2	8			3			4	17
	Sterculia sp.				1	1	3	1	2				8	4	1	8	18	47
	Sterculia sp.1				2						5			10		11	21	49
	Sterculia sp.2													1				1
	Sterculia sp.3															1	1	2
	Sterculiaceae				2													2
Symplocaceae	*Symplocos sp.*				1	3	1		3	2	1			5		8	9	33
	Symplocos sp.1														2			2
	Symplocos sp.2													3	2			5

Tectraria group	*Arcypteris irregularis*				1													1
	Tectraria sp.						1											1
Theaceae	*Adinandra sp.*				2	7	9	5	4		2							29
	Ternstroemia sp.							1										1
	Tetramerista glabra Miq.		1															1
	Tetramerista sp.					2	1	11										14
Theaeceae	*Camellia lanceolata Seem.*	1																1
Thelypteridaceae	*Pronephrium rubicundum*									8								8
Thymelaeaceae	*Aquilaria beccariana van Tiegh.*							1		2								3
	Aquilaria malaccensis Lam.	3												3			4	10
	Aquilaria sp.					1												1
	Enkleia malaccensis Griff.	6			3		1				2			9		15	24	60
	Enkleia sp.					3	6											9
	Gonystylus affine				1													1
	Gonystylus macrophyllus												1					1
	Gonystylus sp.													1	2	3	6	12
	Gonystylus velutinus Airy Shaw		1															1
Tiliaceae	*Brownlowia peltata Benth.*								41	3	11	10	11		13	2		91
	Grewia fibrocarpa Mast.	1	1	2														4
	Grewia paniculata					3	1											4
	Grewia sp.						1	3	3				1					8
	Microcos cinnamomifolia (Burret) Stapf ex P.S.Ashton	2																2
	Microcos crassifolia Burret		4							1	1						2	8
	Microcos sp.						1	1		2				1	2			7
	Microcos tomentosa Sm.				6						1			2		6	1	16
	Pentace adenophora Kosterm.		1											2				3
	Pentace erectinervia Kosterm.										2							2
	Pentace laxiflora Merr.									6	2							8
	Pentace sp.				5						1	4	1		2	3		16
	Pentace sp.1	9	34	4														47

Trigoniaceae	*Trigoniastrum hypoleucum Miq.*	2			1													3
	Trigoniastrum sp.				7											3		10
	Trigoniastrum sp.1				1													1
	Trigoniastrum sp.2				5													5
Ulmaceae	*Gironniera nervosa Plancoh.*									5	4			2				11
	Gironniera subaequalis Planch.					5		3	2									10
Urticaceae	*Dendrocnide sp.*		7							12			2	2	2			25
	Laportea sp.												1					1
	Orophea sp.						1		1									2
	Poikilospermum sp.									1	1				3	1		6
	Urticaceae							3	8			5	201					217
Verbenaceae	*Callicarpa longifolia Lam.*									9	2							11
	Callicarpa sp.		7												6	1		14
	Clerodendron sp.									2	3				2			7
	Geunsia pentandra Merr.									2								2
	Geunsia sp.												1					1
	Teijsmanniodendron sp.		8	5	3	26	5	17	1	2			5	31	2	2	8	115
	Teijsmanniodendron bogoriense Koord.																7	7
	Teijsmanniodendron sp.1																2	2
	Vitex sp.											3	3					6
Vitaceae	*Ampelocissus Borneensis*				2													2
	Ampelocissus imperialis										1					1	5	7
	Ampelocissus sp.	3	1	3	6													13
	Cayratia sp.															2		2
	Cayratia sp.1		77															77
	Cayratia sp.2	1																1
	Cissus sp.			2							5							7
	Pterisanthes sp.										6							6
	Pterisanthes sp.1														1			1
	Tetrastigma manubriatum													5				5
	Tetrastigma sp.				1		1		6	5	4	3			4	1	2	27

	Tetrastigma sp.1													1				1
	Vitaceae sp.														1			1
	Vitaceae sp.1															1		1
	Vitis sp.							2	4	3			1					10
Zingiberaceae	*Alpinia aquatica Rosc.*	13	7	5														25
	Alpinia galanga Willd.		19	4	1													24
	Alpinia ligulata									13	21							34
	Alpinia sp.			1	12	2	45		40	224	104	33	55	15	3	16	34	584
	Alpinia sp.1		4															4
	Amomum sp.								11	34								45
	Costus globosus									309	1							310
	Costus sp.						13	1	231	84	17	61	36		8			451
	Costus speciosus (Koenig) Smith										1							1
	Etlingera littoralis									27								27
	Etlingera sp.					1	4			57	13							75
	Globba sp.		29	3	5		24	13	49	20	6	52	31	2	7	14	4	259
	Globba sp.1		5															5
	Hornstedtia sp.													4	8			12
	Hornstedtia sp.1														5		12	17
	Hornstedtia sp.2														2			2
	Plagiostachys cf. breviramosa									21								21
	Plagiostachys sp.										231							231
	Zingiber sp.									8					2	1	2	13
	Zingiber sp.1								118			33	104	2	3	5	9	274
	Zingiber sp.2								4				1		2	1		8
	Zingiber sp.3					34	251	21	129				1					436
	Zingiber sp.4								11				1					12
	Zingiber sp.5								56				1					57
	Zingiber sp.6												1					1
	Zingiber sp.7												1					1
	Zingiber sp.8												1					1
	Zingiber sp.9												1					1

	Zingiber sp. 10											241	32					273
	Zingiber sp.11													1				1
	Zingiber sp.12												1					1
NA	*Indet*				1					32	5		3			1	1	43
	Indet 1													45	1			46
	Indet 2													2	1			3
	Indet 3														2			2
	Indet 4														2			2
	Indet 5														2			2
	Indet 6													2				2
	Indet 7														1			1
	Indet 8															7		7
	Number of seedlings/0.05 ha	3680	5810	4447	5479	4257	5839	4539	5621	3748	3430	2140	1840	8160	3460	6300	8431	77181
	Number of species/0.05 ha	193	176	167	289	178	164	159	178	269	272	153	153	271	273	274	242	1022

Appendix 7. Notes on permanent sample plot methods used by CIFOR in the Bulungan Research Forest (1998/99).

NOTE: THIS IS INTENDED AS A QUICK WORKING DRAFT TO LEAVE WITH THE PROJECT.

COMMENTS AND CORRECTIONS ARE NEEDED AND WOULD BE WELCOME.

The main data sheet

This sheet contains the main tree data (species, diameter [and details of the measurement], crown position), standing dead wood (dead trees) and tree cavities. All stems with a girth at 1.3 m of 62 cm and over are recorded, this includes palms, climbers, dead trees and any other form of stem that qualifies by virtue of its diameter.
The form has the following layout – superscripts are used to provide explanations below.

BRFCIFOR: SFM Plot Data sheet													
Petak[1]		**Plot**[2]	**Date (d-m-y)**[3] Tanggal (h-b-t)				**Recorder**[4] Pencatat						
Team[5]			**Page ___ of ___**[6] Halaman			***(office) Input by***[7]	***(office) File name***[8] **Date**[9]						
Subplot[10]	**Stem number** Nomor[11]	**Name** Nama[12]	**Girth** Keliling **(cm.mm)**[13]	**h** tinggi ukur **(m)**[14]	**p.o.m. Code** Kode titik ukur[15]	**Crown Pos' (1-5)**[16]	**Cavities** Lubang **(1-3)**[17]	**Dead** Mati[18]	**CWD** Limbah Kayu Kasar[19]	**Stem length if broken (m)**[20]	A1 (Tanget)[21]	A2 (Tangent)[22]	**Trees High Actual(m)**[23]

Sheet headers

1 *Petak* is the name of the actual forest block or compartment being worked in, e.g. 27a.

2 *Plot* is the name of the plot, e.g. 'H3'

3 *Date* is the day of the field observations being recorded (day/month/year).

4 *Recorder* is the name of the field booker – the person who has filled in the sheet. This person is responsible for ensuring that the final sheets are free of careless errors, and should check and initial each sheet upon completion to show they have been completed and checked.

5 *Team* is for names of other team members. These may be called upon to clarify or comment upon any discrepancies in the data.

6 *Page _ of _* records the number of pages out of a total for the whole plot. This is checked and completed when the plot is finished. These will be used to organise the sheets and check for omissions.

7 *This is not filled in the field* (when the data is computer inputted the person responsible fills in their name)

8 *This is not filled in the field* (this is the file name given to the computer entered data)

9 *This is not filled in the field* (this is the data the file of computer entered data is created).

Column headers

10 *Subplot* is the location of the stem observations being made on this row. The number comes from the south-west tag within the local 20 by 20 m grid square. The subscripts ***a, b, c, d***, are added to denote the south-west, south-east, north-west, and north-east quarters of this square (i.e. each 10 by 10m has a unique name). The grid layout is pictured in Fig 1.

11 *Stem number* is the number painted on the stem. These are given sequentially to each new stem recorded. Each stem in the plot has a unique number. Note that on multi-stemmed individuals each *stem* receives a different number.

12 *Name* is the recorded taxonomic information. What to record here (or whether it is to be left blank in the field) depends upon arrangements made for identification.

13 *Girth* is the measured circumference of the stem recorded and rounded to the nearest tenth of a cm (i.e. mm). Each measure must conform to the agreed conventions (see sheet on how to measure stems. Fig 2)

14 *h* is the height or distance along the stem from the ground to the point of measurement. In most cases this will be 1.3 m (one meter and thirty centimetres), but in specific cases different h's will be needed (see Fig 2). The maximum h to be used (e.g. on high buttresses) is 3m, i.e. if buttresses or deformities continue above 3m the measure is still made at 3m.

15 *p.o.m. code* (point of measurement code) records the reason why a particular stem measurement may have been difficult either in terms of access to a suitable p.o.m. or in determining where the p.o.m. should be. A p.o.m. code is always needed when *h* is not 1.3m dbh.

P.O.M. Codes

B	Buttresses
F	Fallen stem (prone, but still alive)
ML	Multiple low branching stems
MH	Multiple high branching stems
JA	Joining above (multiple stems on one plant)
C	Curved or angled stem
D	deformity at 1.3.m (
BAP	Branch at 1.3m
Irreg	Irregular
CS	Coppice sprout
LS	Low sprout/shoot/stem
BA	Broken above (the actual tree is a sprout above the measurement)
SFF	Sprout/shoot/stem from fallen
SR	Stilt roots

IS Intimate stems (p.o.m. difficult as two or more stems are pressed against each other) – note this was omitted from the reference sheet.

IC Intimate climber (measure difficult due to one or more climbers/lianas/strangler obscuring the p.o.m.) – note this was omitted from the reference sheet.

16 *Crown position* is a simple 1-5 classification of a tree's crown position with respect to direct incident light.

1 Crown receives no direct sunlight, being totally shaded.

2 Crown receives some direct sunlight from the sides, but none from above.

3 Crown receives some direct sunlight from above

4 Whole crown receives full overhead light, but not a full unimpeded cone with sides 45^o from the vertical

5 Whole crown receives direct light within a cone with sides 45^o from the vertical.

17 *Cavities* records holes within the tree bole up to a height of 10m. Each cavity is classed by size on a scale 1-3. Multiple cavities require multiple entries (i.e. for three cavities with classes 1, 1 and 3 '1,1,3' is entered). Cavities must be real hollows, not bark wounds. Each stem should be observed from the four major compass points (north, south, east and west).

The three cavity classes are:

1: Openings < 100 cm^2 (the maximum size is approximately the size of a fist)

2: Openings 100-400 cm^2 (a square opening of the maximum size would have a width of 20 cm)

3: Openings > 400 cm^2 (a square opening of the minimum size has a width of 20 cm)

18 *Dead* is ticked if a stem is dead. Dead stems are included if they have a measured circumference at 1.3 m of 62 cm or over. Slashing the stem to check for live sappy tissue IS permitted on leafless stems. Note dead stems are included in all measures except for crown position. This will include any large stumps more than 1.3 m in height, leaning and fallen trees held by other vegetation ('snags') – but not fallen stems lying prone on the ground (though their stumps may qualify if these are snapped stems).

19 *CWD* (coarse woody debris) is a 1-4 classification of decay applied only to dead stems. The four stem-decay classes are:

1: Wood hard, bark on, (small branches and/or twigs <1 cm diameter often present)

2**: Wood soft on outside (knife blade easily embedded to 1-2 cm)**

3**: Wood soft throughout but some structural integrity remaining (knife easily embedded > 2 cm, bark and branches usually absent)**

4: Wood soft throughout and structural integrity very low (collapsed stem or collapsible under slight pressure, bark and branches absent).

The class is assessed at several points on the stem between 1-1.5 m above the ground. The most advanced decay class is recorded.

20 *Stem length if broken* is used if the stem is broken above the measure. The length of the remaining stem (ground to break point) is recorded (estimated) in meters. Note that this applies to **living and dead** trees.

21 A1(Tangent 1) record from the clinometer for calculating trees hight actual

22 A 2 (Tangent 2) record from the clinometer for calculating trees height actual

An example of a partially completed form might be as follows:

BRFCIFOR: SFM Plot Data sheet

Petak[1]	Plot[2]		Date (d-m-y)[3] Tanggal (h-b-t)				Recorder[4] Pencatat						
Team [5]			Page ___ of ___[6] Halaman			*(office) Inputted by*[7]	*(office) File name*[8] Date[9]						
Subplot [10]	**Stem number** Nomor [11]	**Name** Nama [12]	**Girth** Keliling **(cm.mm)** [13]	**h** tinggi ukur **(m)** [14]	**p.o.m. Code** Kode titik ukur [15]	**Crown Pos' (1-5)** [16]	**Cavities** Lubang **(1-3)**[17]	**Dead** Mati [18]	**CWD** Limbah Kayu Kasar [19]	**Stem length if broken (m)** [20]	A1 (Tanget)[21]	A2 (Tangent)[22]	**Trees High Actual(m)** [23]
01	1	Garcinia sp.	65.2	1.3		4							
01	2	Shorea sp.2	76.0	1.6	Irreg	-	3,3,2	V	2	22			
01	3	Santiria oblongifolia Blume	120.5	2.1	B	4							
01	4	Dillenia excelsa (Jack) Gilg	62.0	1.3		3	2						
01	5	Teijsmanniodendron sp.	89.6	1.3		3							
01	6	Saraca sp.	223.3	3	B	5							
01	7	Shorea sp.2	….										

Fallen dead wood data sheet

The method is based upon a line intercept procedure. Each grid line, including the plot boundaries, is recorded as a separate transect labelled by the grid post numbers at the line's furthest end points. In each plot there are 12 100 meter transects, six running north-south and six running east-west. Where ever the line crosses a piece of fallen wood the diameter of that piece is assessed perpendicular to its grain at that point. If the diameter is greater than or equal to 10 cm it is recorded on the data sheet, with the diameter rounded down to the nearest five cm (i.e. the lowest class is 10 cm, the next is 15 etc.). If the piece is non-circular at the point where the line crosses, two further considerations must be made: 1). Is the piece squashed or crushed out of shape? (If so it is acceptable to move the measure to the nearest point on the piece where the 'true' diameter may be assessed, or alternatively, to estimate a likely 'true' diameter); 2). The overall condition of the log is recorded with respect to decay state and wholeness. These two conditions are outlined below.

The decay-state of the wood is classified on a scale of 1 to 4:

1: Wood hard, bark on, (small branches and/or twigs <1 cm diameter often present)

2**: Wood soft on outside (knife blade easily embedded to 1-2 cm)**

3**: Wood soft throughout but some structural integrity remaining (knife easily embedded > 2 cm, bark and branches usually absent)**

4: Wood soft throughout and structural integrity very low (collapsed stem or collapsible under slight pressure, bark and branches absent).

Wholeness is assessed by noting whether the log is hollow and/or complete at the point where the transect line crosses the log. If a log is only half or a quarter present, this is indicated in the notes section of the data sheet by writing "one half log" etc. If a log is hollow at the transect intercept, the percent to which it is hollow is subjectively assessed at 4 levels: 25, 50, 75, and 100 percent. Record this percent in the *notes* section of the data sheet.

Stumps (less than 1.3 m in height) are recorded by their diameter just above the roots. These records are labelled as 'stump' in the notes.

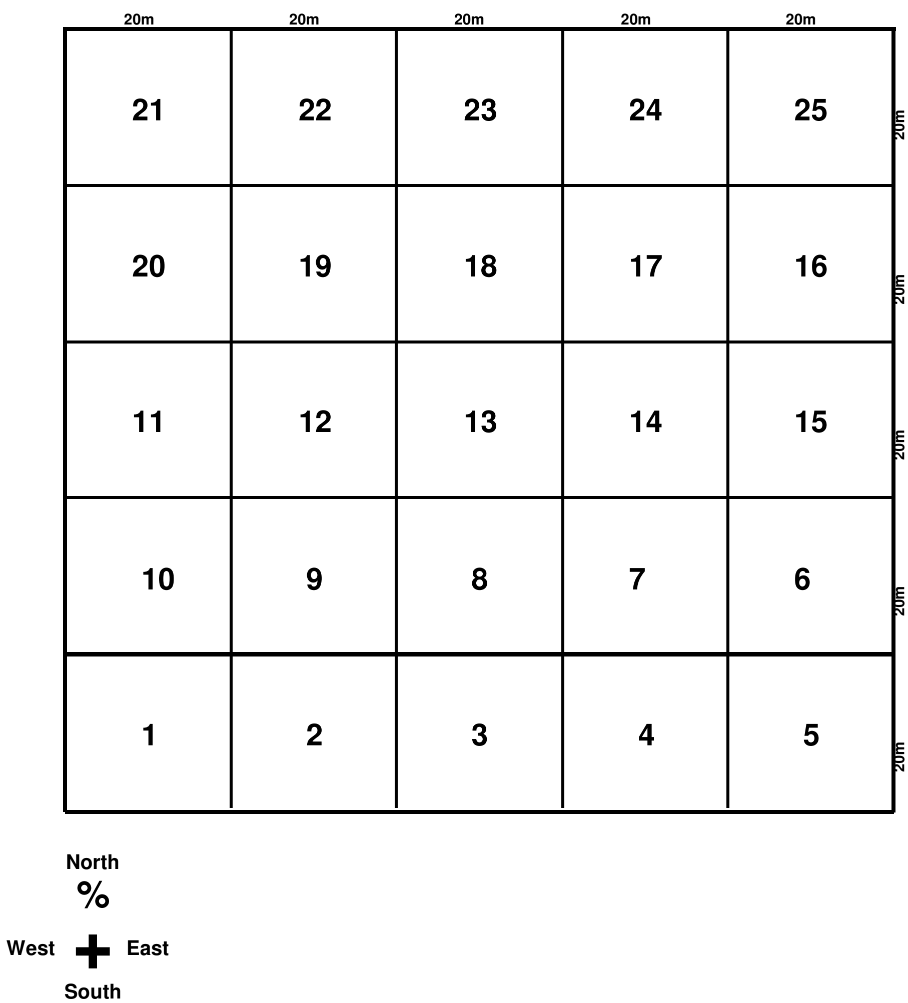
Canopy closure data sheet

Densiometer records are made just to the west of each of the 36 grid points (make sure that the stake at each point and the recorder's head are not included by the densiometer). At each stake four readings are made; one at north, south,-east and west.

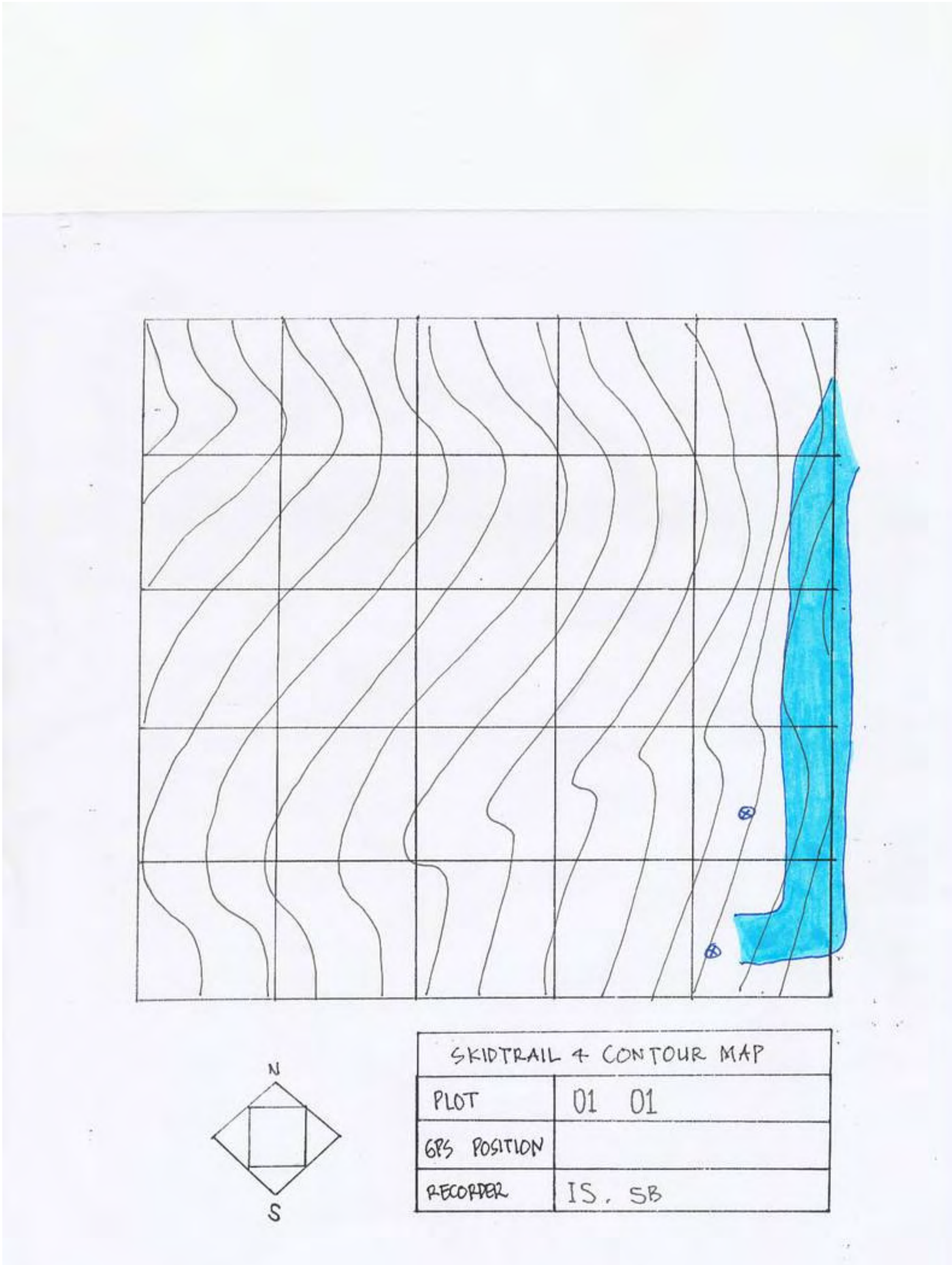
The densiometer is held at 'elbow-height', and a compass is used to orient the densiometer to north, south, east and west. Full instructions for use are provided on the inside of the densiometer lid. Note that each of the four densiometer readings will be between zero and 96 (do not make any corrections to make this 1-100, this will be done later in the computer).

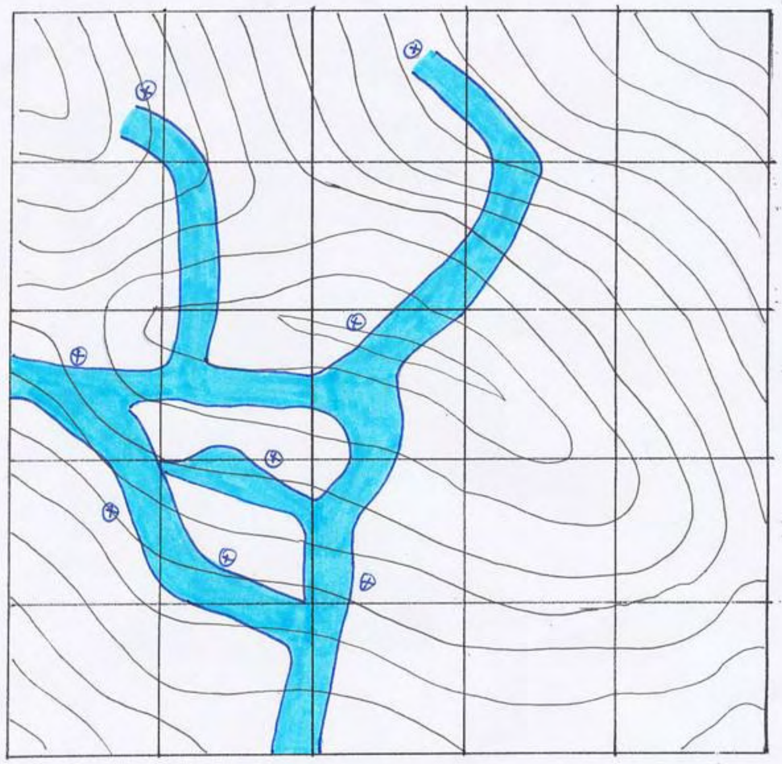
D.S. 29/10/98. With thanks to Hari, Aep, Sigit, Ellen, Phil, Pak Riswan and Ismayadi for their hard work and for their feedback on these methods.

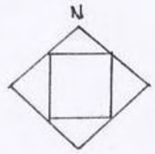
CIFOR - Permanent Sample Plot (Bulungan). Subplot and grid labels.



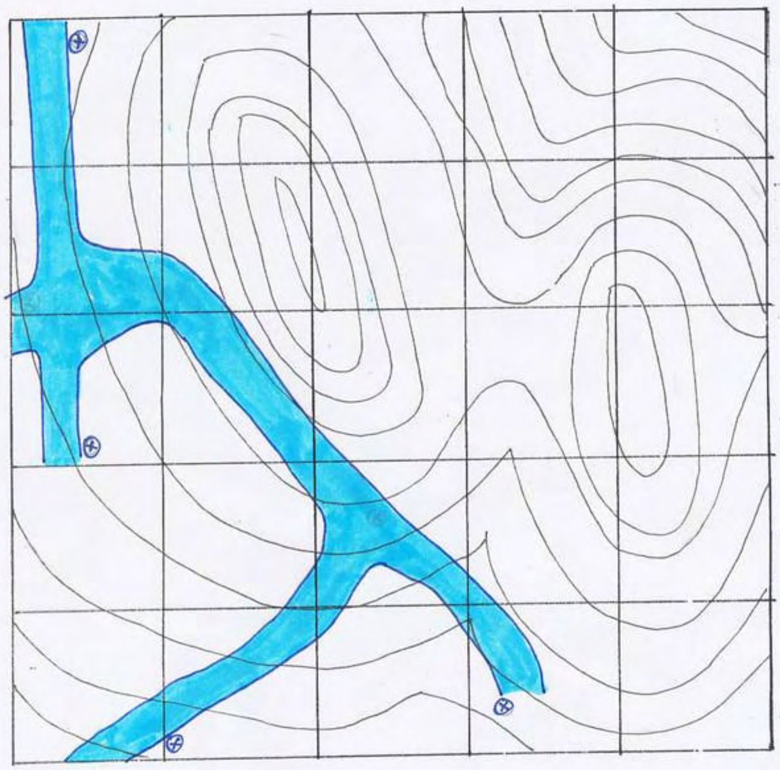
Appendix 8. Skid trail maps of each plot in LF-5, LF-10 and LF-30.

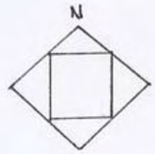




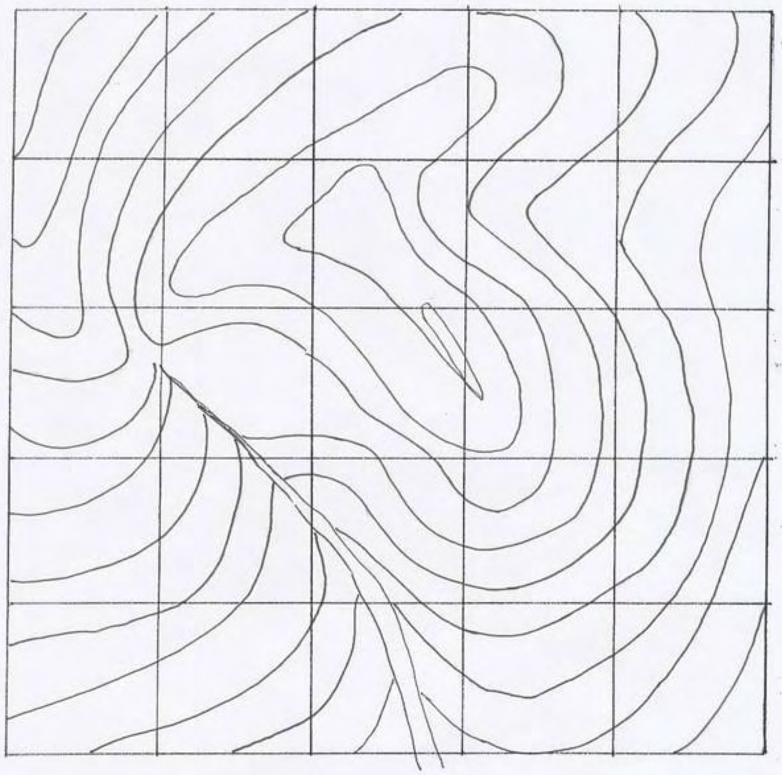


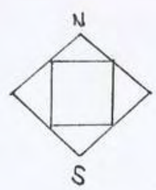
SKIDTRAIL + CONTOUR MAP	
PLOT	01 02
GPS POSITION	
RECORDER	IS , SB



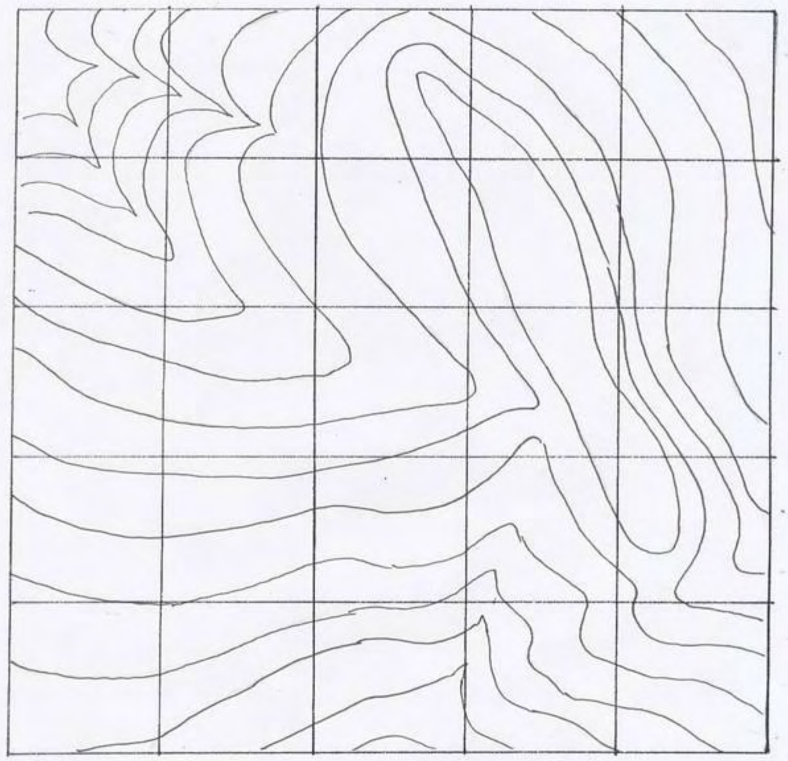


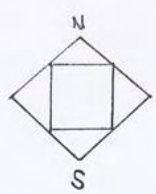
SKIDTRAIL 4 CONTOUR MAP	
PLOT	01 04
GPS POSITION	
RECORDER	IS, SB



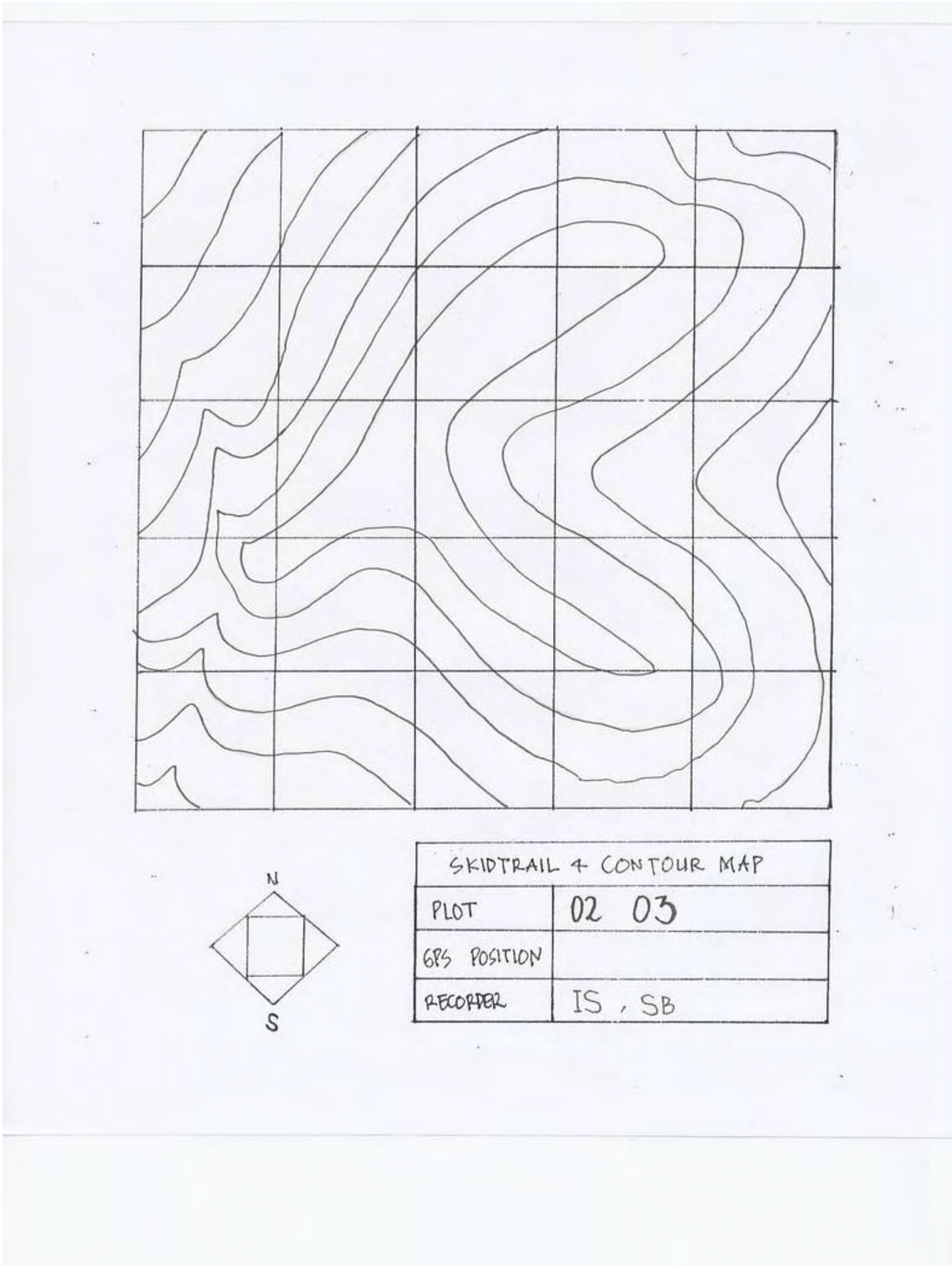


SKIDTRAIL 4 CONTOUR MAP	
PLOT	02 01
GPS POSITION	
RECORDER	IS , SB





SKIDTRAIL 4 CONTOUR MAP	
PLOT	02 02
GPS POSITION	
RECORDER	IS , SB


N
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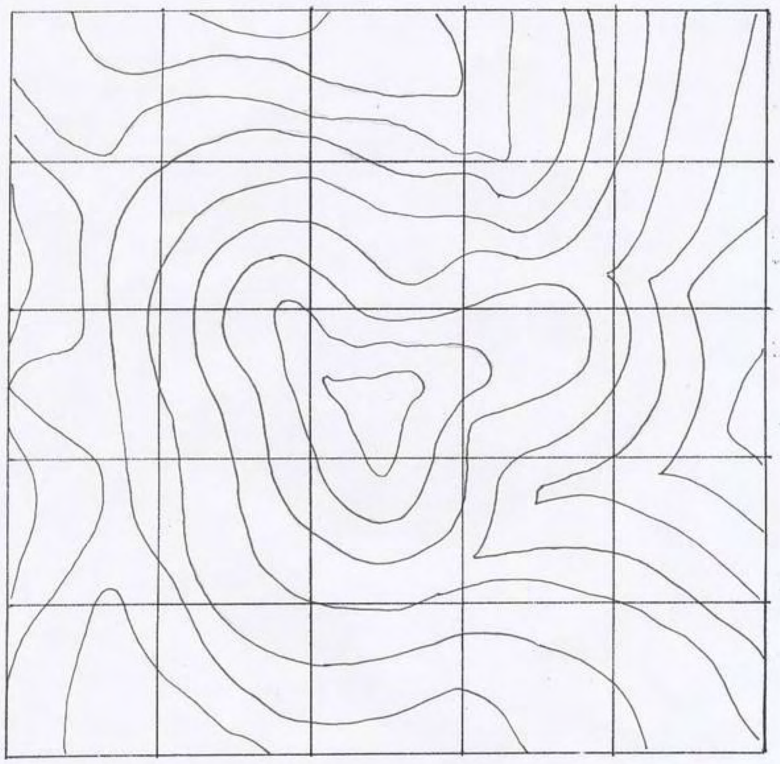
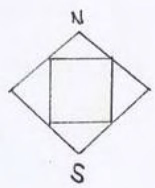
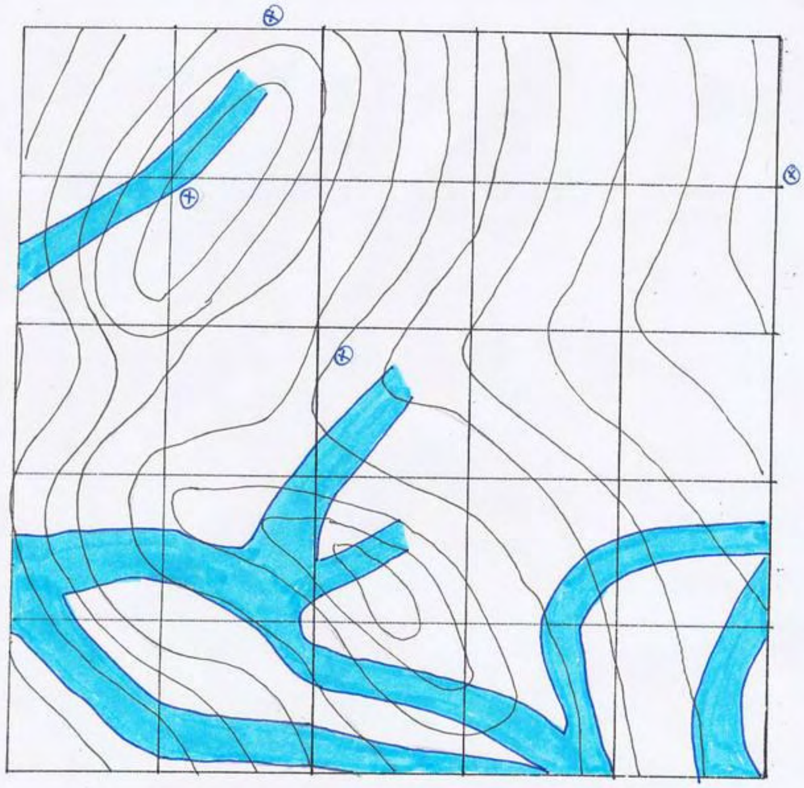
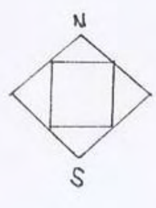
SKIDTRAIL 4 CONTOUR MAP
PLOT
02 03
GPS POSITION
RECORDER
IS , SB



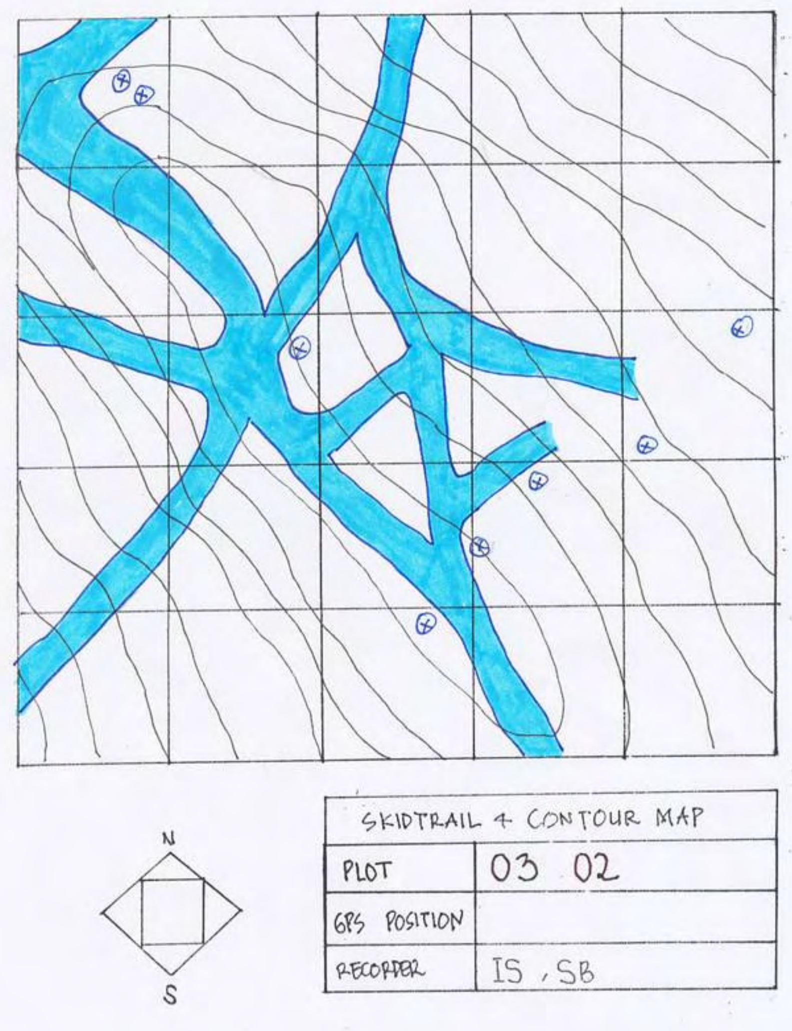


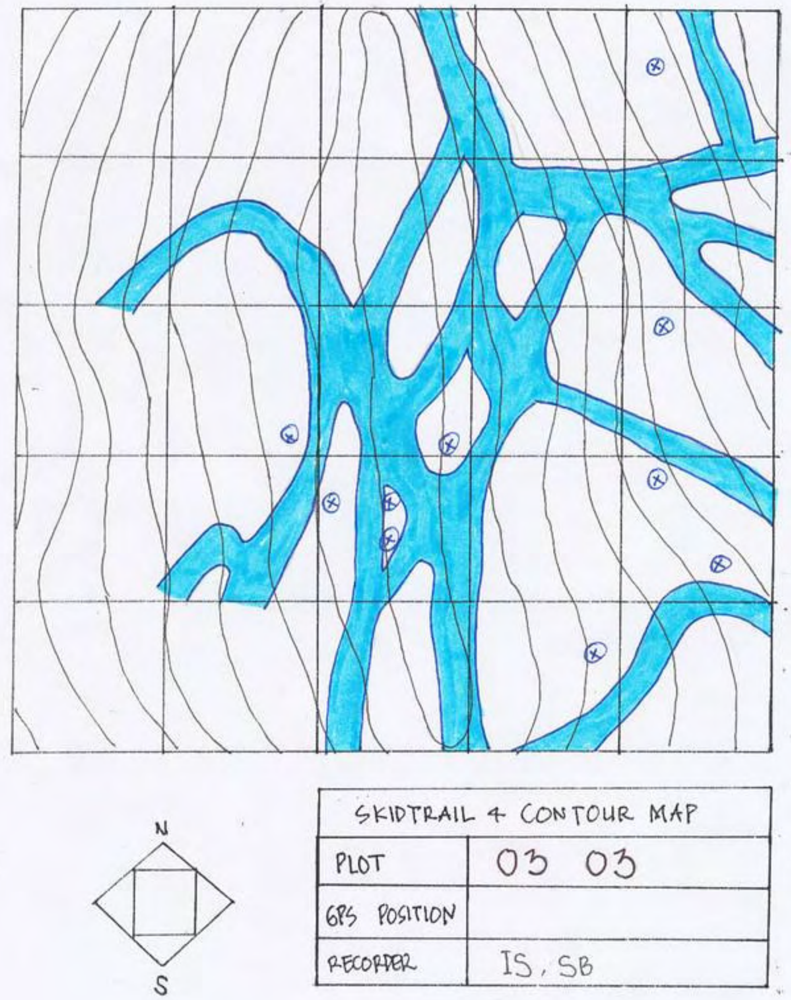
SKIDTRAIL 4 CONTOUR MAP	
PLOT	02 04
GPS POSITION	
RECORDER	IS, SB

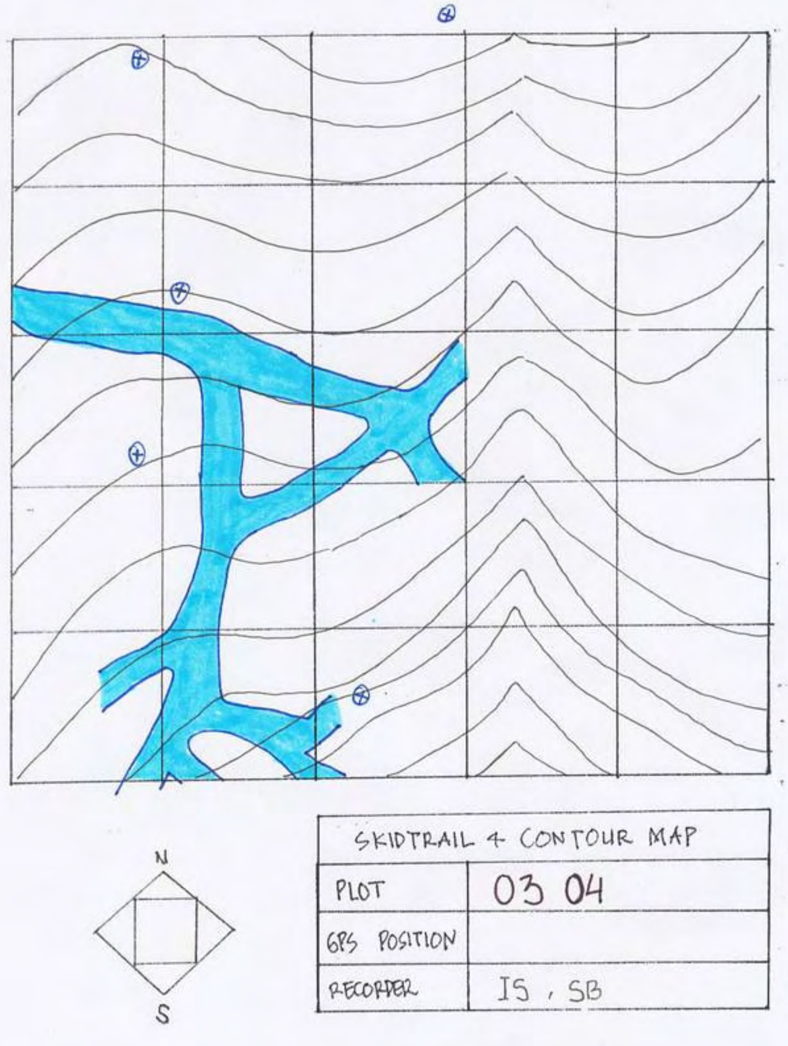


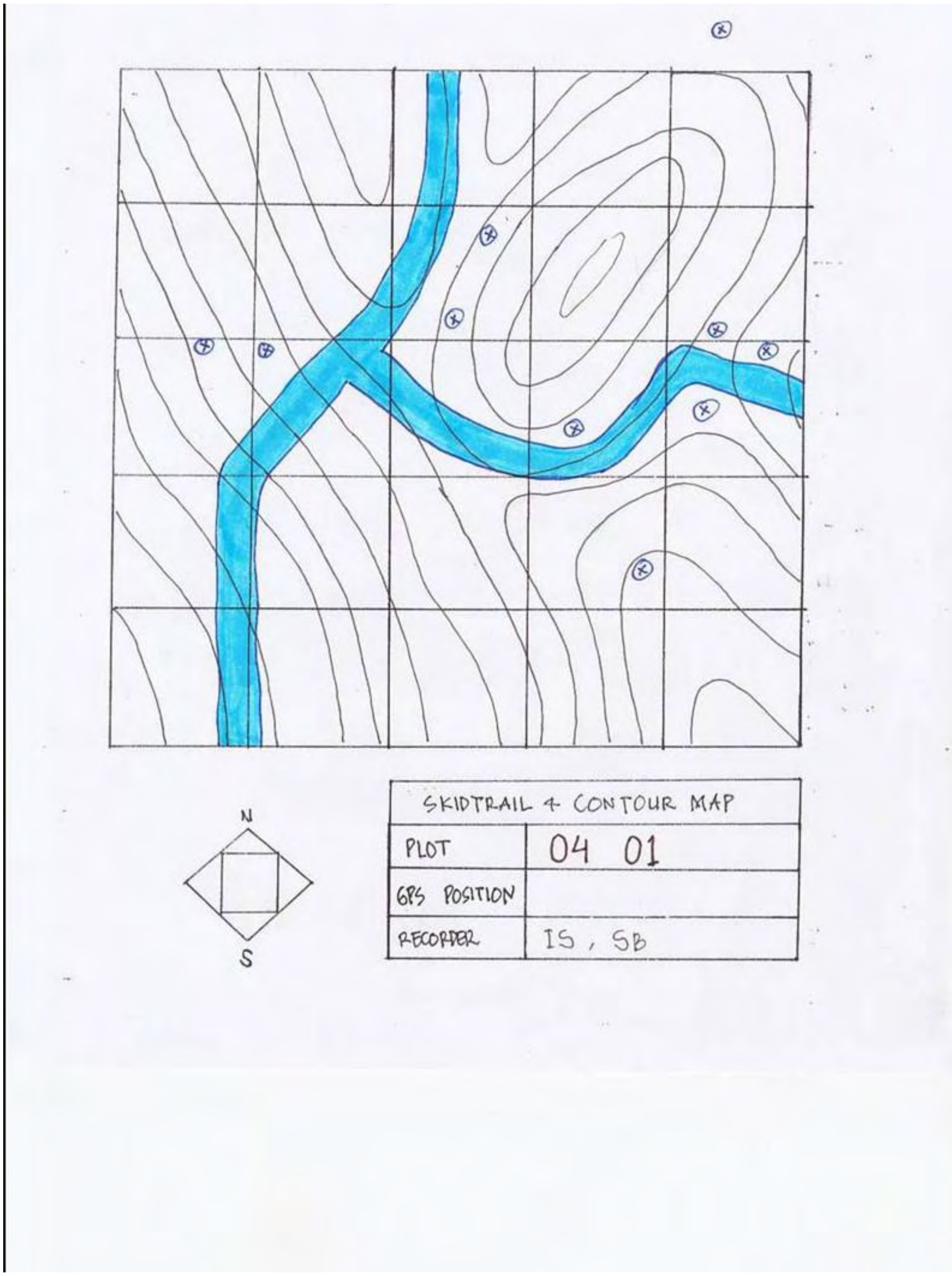


SKIDTRAIL 4 CONTOUR MAP	
PLOT	03 01
GPS POSITION	
RECORDER	IS, SB


SKIDTRAIL + CONTOUR MAP
PLOT
03 02
GPS POSITION
RECORDER
IS , SB
N
S


N
S
SKIDTRAIL 4 CONTOUR MAP
PLOT
03 03
GPS POSITION
RECORDER
IS, SB


SKIDTRAIL + CONTOUR MAP
PLOT
03 04
GPS POSITION
RECORDER
IS , SB
N
S


N
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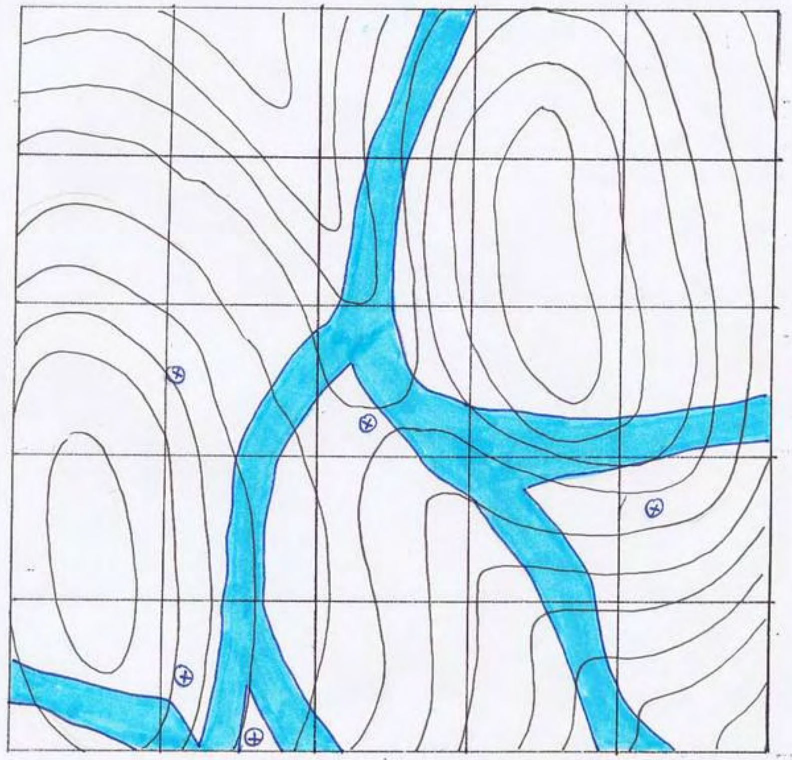
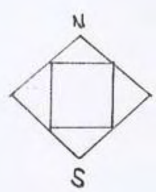
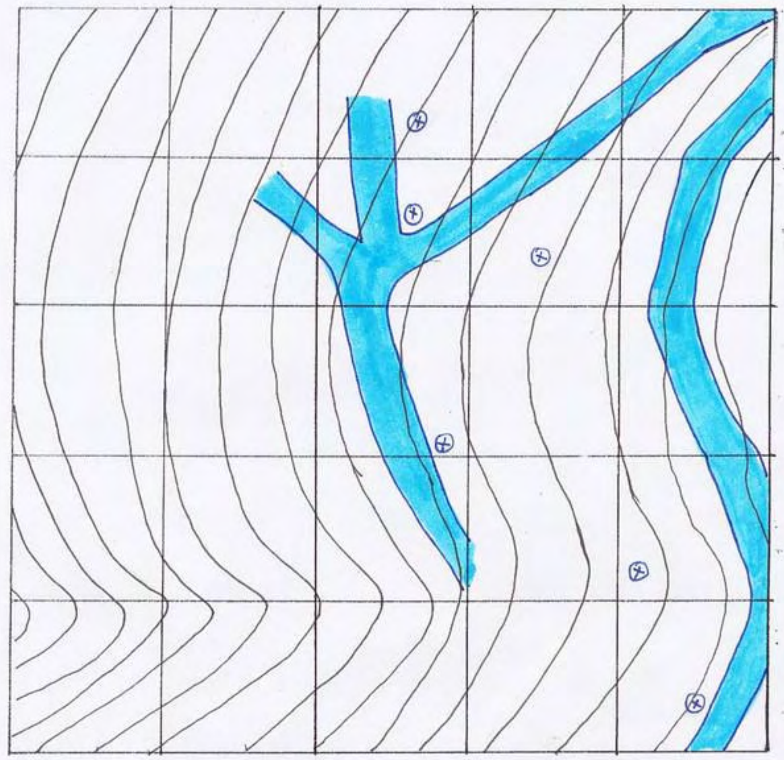
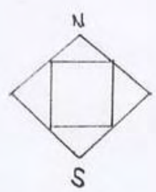
SKIDTRAIL + CONTOUR MAP
PLOT
04 01
GPS POSITION
RECORDER
IS, SB



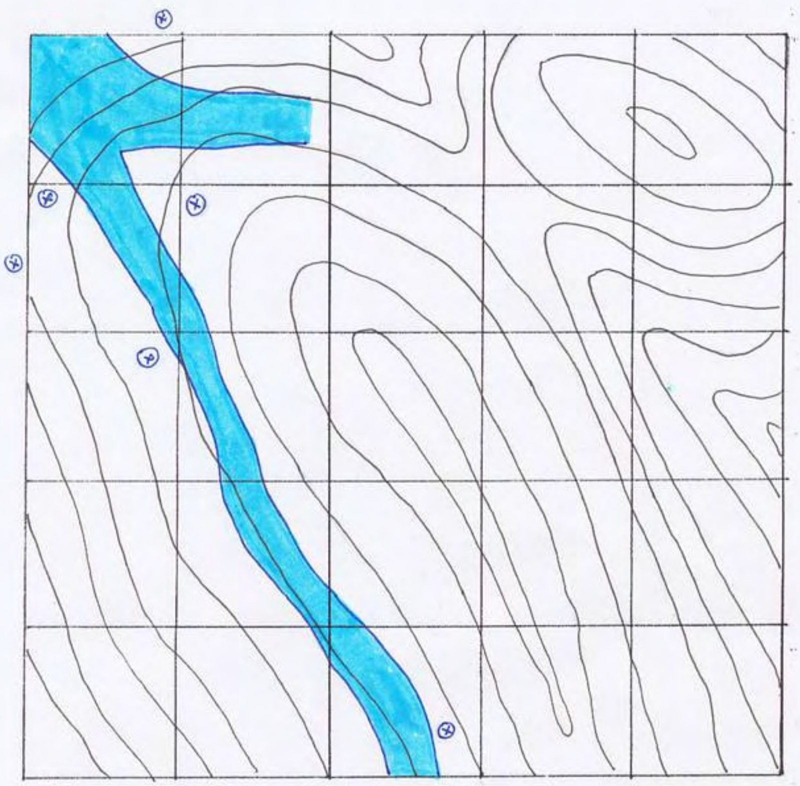


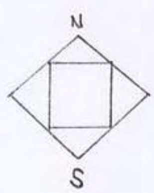
SKIDTRAIL & CONTOUR MAP	
PLOT	04 02
GPS POSITION	
RECORDER	IS, SB





SKIDTRAIL + CONTOUR MAP	
PLOT	04 03
GPS POSITION	
RECORDER	IS, SB





SKIDTRAIL + CONTOUR MAP	
PLOT	04 04
GPS POSITION	
RECORDER	IS , SB

Appendix 9. Soil data tabulation

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
1	6302	1	1	1	1	211.80	56.8	28.5	10.8	3.9	3.8	3.8	1.35	0.11	12	5.0	0.38	0.15	0.11	0.05	0.69	4.68	15	4.95	0.41	29.18
2	6303	1	1	1	1	209.63	59.2	28.4	8.4	4.0	3.6	3.6	1.11	0.09	12	13.6	0.22	0.17	0.13	0.04	0.56	5.55	10	5.19	0.42	54.00
3	6343	1	1	1	1	253.66	58.1	27.2	9.0	5.7	3.9	3.8	0.78	0.07	11	2.6	0.30	0.12	0.11	0.07	0.60	3.78	16	3.09	0.55	27.93
4	6344	1	1	1	1	259.87	49.6	29.3	11.8	9.3	4.2	3.8	0.72	0.07	10	3.7	0.73	0.33	0.13	0.02	1.21	4.75	25	3.70	0.30	27.93
5	6345	1	1	1	1	216.61	52.3	29.0	10.4	8.3	4.0	3.7	1.13	0.11	10	4.0	0.81	0.41	0.15	0.02	1.39	5.58	25	3.98	0.24	29.80
6	6304	1	1	2	1	216.81	43.9	34.5	15.2	6.4	3.6	3.6	1.18	0.11	11	4.2	0.30	0.14	0.13	0.02	0.59	7.10	8	7.38	0.65	29.18
7	6347	1	1	2	1	234.47	50.9	26.4	13.1	9.6	3.8	3.8	0.85	0.08	11	7.3	0.15	0.06	0.07	0.07	0.35	5.35	7	5.51	0.32	30.62
8	6348	1	1	2	1	220.55	37.9	39.2	14.4	8.5	3.6	3.6	1.51	0.11	14	8.2	0.10	0.11	0.07	0.08	0.36	6.57	5	7.62	0.58	35.90
9	6349	1	1	2	1	193.48	39.9	36.4	13.6	10.1	3.6	3.6	1.44	0.12	12	4.8	0.15	0.14	0.07	0.03	0.39	7.43	5	7.53	0.53	28.51
10	6350	1	1	2	1	214.06	40.1	36.8	14.8	8.3	3.6	3.6	1.44	0.11	13	7.9	0.15	0.14	0.07	0.04	0.40	7.35	5	7.17	0.76	32.74
11	6620	1	1	3	1	-	49.0	27.0	11.0	13.0	3.8	3.7	0.77	0.05	15	7.8	0.21	0.21	0.09	0.06	0.57	7.13	8	4.40	0.10	8.42
12	6621	1	1	3	2	-	42.0	28.0	18.0	12.0	4.0	3.8	0.34	0.03	11	6.4	0.47	0.18	0.09	0.03	0.77	7.88	10	5.24	0.15	10.58
13	6618	1	1	4	1	-	36.0	33.0	19.0	12.0	4.0	3.8	0.73	0.05	15	28.9	0.73	0.24	0.16	0.21	1.34	8.66	15	6.12	0.21	3.16
14	6619	1	1	4	2	-	33.0	33.0	22.0	12.0	4.0	3.8	0.33	0.03	11	29.9	0.17	0.07	0.09	0.04	0.37	8.25	4	5.84	0.19	15.02
15	6305	1	2	1	1	244.31	55.2	28.1	11.3	5.4	4.6	4.0	0.92	0.11	8	2.6	4.93	0.43	0.18	0.05	5.59	5.71	98	1.39	0.03	30.42
16	6306	1	2	1	1	246.42	44.0	36.0	12.2	7.8	4.1	3.7	1.05	0.11	10	5.8	0.90	0.33	0.18	0.04	1.45	7.48	19	6.70	0.55	29.18
17	6307	1	2	1	1	262.03	30.1	51.2	13.2	5.5	4.9	4.3	1.31	0.16	8	6.7	5.92	1.90	0.27	0.05	8.14	8.02	>100	0.39	0.04	55.25
18	6346	1	2	1	1	239.21	71.2	19.3	5.7	3.8	4.2	3.8	1.00	0.10	10	8.0	1.43	0.23	0.13	0.02	1.81	4.43	41	2.27	0.22	11.90
19	6351	1	2	1	1	285.35	63.9	20.2	9.7	6.2	4.1	3.8	1.06	0.11	10	7.1	1.41	0.28	0.07	0.03	1.79	5.02	36	3.38	0.31	41.71

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
20	6352	1	2	2	1	249.10	55.8	28.1	9.2	6.9	3.9	3.7	0.87	0.08	11	3.5	0.36	0.29	0.07	0.07	0.79	5.48	14	5.32	0.40	43.82
21	6353	1	2	2	1	244.78	38.3	33.2	13.2	15.3	4.6	3.7	1.15	0.10	12	5.3	1.09	0.17	0.14	0.12	1.52	8.75	17	3.47	0.37	33.70
22	6354	1	2	2	1	274.28	43.1	32.6	14.6	9.7	4.4	3.9	0.80	0.07	11	5.9	4.22	1.11	0.10	0.06	5.49	7.60	72	3.62	0.18	29.04
23	6355	1	2	2	1	160.32	43.6	35.9	11.2	9.3	3.9	3.6	1.69	0.16	11	11.5	0.68	0.25	0.14	0.05	1.12	7.87	14	6.50	0.45	54.38
24	6356	1	2	2	1	228.12	54.4	31.0	8.4	6.2	4.2	3.9	1.05	0.09	12	5.2	1.03	0.39	0.07	0.07	1.56	5.12	30	3.63	0.43	33.79
25	6624	1	2	3	1	-	43.0	37.0	14.0	6.0	4.0	3.7	0.72	0.05	14	9.3	0.53	0.32	0.10	0.11	1.06	10.06	11	6.46	0.07	9.79
26	6625	1	2	3	2	-	41.0	37.0	16.0	6.0	4.2	3.7	0.30	0.02	15	6.5	0.35	0.23	0.09	0.12	0.79	10.98	7	8.22	0.33	4.18
27	6622	1	2	4	1	-	43.0	27.0	17.0	13.0	3.6	3.5	0.84	0.06	14	6.2	0.43	0.28	0.09	0.12	0.92	11.61	8	9.40	0.35	10.62
28	6623	1	2	4	2	-	37.0	28.0	23.0	12.0	3.8	3.6	0.61	0.05	12	6.4	0.26	0.15	0.09	0.12	0.62	14.40	4	11.06	0.49	10.23
29	6381	1	3	1	1	228.30	59.0	23.8	11.7	5.5	4.1	3.7	1.41	0.10	14	4.5	0.20	0.15	0.07	0.01	0.43	5.89	7	4.60	0.37	18.48
30	6382	1	3	1	1	224.92	45.5	35.6	8.1	10.8	4.2	3.7	0.93	0.07	13	3.5	0.15	0.28	0.07	0.01	0.51	6.36	8	5.78	0.46	61.25
31	6384	1	3	1	1	252.83	49.5	29.3	11.7	9.5	3.8	3.7	1.10	0.10	11	12.3	0.21	0.17	0.11	0.02	0.51	6.71	8	6.81	0.43	70.22
32	6385	1	3	1	1	222.70	60.5	27.3	7.5	4.7	5.3	4.9	1.74	0.12	15	4.5	7.79	0.84	0.07	0.01	8.71	6.67	>100	0.04	0.10	32.21
33	6390	1	3	1	1	219.76	29.8	37.9	16.3	16.0	4.1	3.7	1.03	0.10	10	4.3	0.72	0.15	0.07	0.01	0.95	7.73	12	8.24	0.48	15.84
34	6383	1	3	2	1	239.50	57.1	33.5	1.2	8.2	4.0	3.7	1.11	0.09	12	12.1	0.31	0.16	0.14	0.08	0.69	6.53	11	6.42	0.56	54.38
35	6386	1	3	2	1	256.71	64.1	16.2	13.4	6.3	4.3	3.8	1.16	0.08	15	5.4	0.26	0.09	0.07	0.00	0.42	6.49	6	5.68	0.32	62.30
36	6387	1	3	2	1	247.66	46.7	19.3	25.9	8.1	4.2	3.7	0.87	0.07	12	7.0	0.87	0.22	0.07	0.00	1.16	6.91	17	7.81	0.35	29.04
37	6388	1	3	2	1	255.49	32.6	38.9	15.8	12.7	3.9	3.7	1.64	0.13	13	10.3	0.10	0.06	0.11	0.02	0.29	8.31	3	7.97	0.64	25.34
38	6389	1	3	2	1	259.29	47.2	28.3	14.3	10.2	3.7	3.7	1.31	0.12	11	5.4	0.21	0.12	0.09	0.01	0.43	7.24	6	6.65	0.45	18.48
39	6640	1	3	3	1	-	54.0	18.0	18.0	10.0	4.1	3.8	0.40	0.03	13	5.9	0.47	0.22	0.09	0.06	0.84	8.95	9	5.63	0.31	67.53
40	6641	1	3	3	2	-	49.0	17.0	17.0	17.0	4.1	3.8	0.32	0.02	16	7.9	0.13	0.07	0.09	0.22	0.51	8.64	6	6.45	0.17	73.91

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
41	6638	1	3	4	1	-	28.0	35.0	23.0	14.0	3.9	3.7	1.24	0.08	16	7.7	0.04	0.09	0.09	0.06	0.28	14.18	2	10.74	0.47	22.16
42	6639	1	3	4	2	-	25.0	32.0	25.0	18.0	4.2	3.8	0.46	0.03	15	5.9	0.04	0.04	0.07	0.14	0.29	13.35	2	10.57	0.59	103.12
43	6308	1	4	1	1	228.58	64.8	21.6	6.3	7.3	3.7	3.6	1.19	0.09	13	14.4	0.31	0.14	0.14	0.02	0.61	7.41	8	7.97	0.55	44.07
44	6309	1	4	1	1	235.33	74.8	17.4	5.9	1.9	3.7	3.7	1.11	0.09	12	6.5	0.25	0.15	0.17	0.07	0.64	5.31	12	4.68	0.59	24.83
45	6310	1	4	1	1	202.75	70.4	4.7	19.5	5.4	4.0	3.8	1.19	0.08	15	7.0	0.25	0.15	0.13	0.07	0.60	5.14	12	5.12	0.31	29.18
46	6311	1	4	1	1	169.11	41.3	7.9	41.8	9.0	3.7	3.7	1.30	0.09	14	7.4	0.30	0.17	0.13	0.04	0.64	8.41	8	8.73	0.70	36.62
47	6312	1	4	1	1	252.09	52.7	27.9	8.9	10.5	4.0	3.8	0.64	0.06	11	4.7	0.30	0.12	0.11	0.07	0.60	7.05	9	7.15	0.18	16.76
48	6313	1	4	2	1	248.75	73.7	19.3	3.6	3.4	3.8	3.8	0.93	0.07	13	7.1	0.51	0.14	0.11	0.09	0.85	3.93	22	3.53	0.14	17.38
49	6314	1	4	2	1	241.01	66.3	19.5	7.0	7.2	3.9	3.9	1.02	0.07	15	5.5	0.42	0.17	0.15	0.09	0.83	6.51	13	5.56	0.47	25.45
50	6391	1	4	2	1	271.65	62.2	18.0	7.9	11.9	4.2	3.8	0.47	0.04	12	3.5	0.19	0.09	0.08	0.10	0.46	8.02	6	6.76	0.58	23.76
51	6392	1	4	2	1	275.80	45.4	28.7	12.4	13.5	4.4	3.7	0.49	0.04	12	8.7	0.14	0.12	0.08	0.10	0.44	7.60	6	8.62	0.88	30.62
52	6473	1	4	2	1	250.22	9.2	56.7	21.6	12.5	5.1	3.9	0.68	0.08	9	2.9	0.48	1.68	0.35	0.11	2.62	10.71	24	5.70	0.46	34.45
53	6644	1	4	3	1	-	56.0	20.0	11.0	13.0	3.7	3.8	0.93	0.05	19	7.1	0.30	0.12	0.09	0.06	0.57	7.42	8	4.86	0.27	13.21
54	6645	1	4	3	2	-	47.0	23.0	14.0	16.0	4.0	3.8	0.36	0.03	12	9.6	0.17	0.03	0.09	0.12	0.41	8.82	5	6.87	0.05	28.29
55	6642	1	4	4	1	-	69.0	14.0	7.0	10.0	3.9	3.9	0.80	0.04	20	8.6	0.13	0.07	0.09	0.24	0.53	6.81	8	2.89	0.44	15.82
56	6643	1	4	4	2	-	65.0	14.0	9.0	12.0	3.9	4.0	0.47	0.02	24	13.5	0.17	0.09	0.07	0.06	0.39	6.52	6	4.70	0.04	23.78
57	6461	2	1	1	1	120.98	36.9	32.0	18.4	12.7	4.2	3.7	1.69	0.12	14	8.0	0.09	0.17	0.21	0.06	0.53	10.10	5	8.08	0.83	36.93
58	6462	2	1	1	1	167.81	52.2	28.0	8.6	11.2	4.1	3.7	1.33	0.13	10	8.0	0.05	0.14	0.28	0.09	0.56	6.70	8	4.73	0.54	37.24
59	6463	2	1	1	1	156.75	37.7	36.7	18.3	7.3	3.7	3.6	2.29	0.17	13	11.9	0.09	0.20	0.18	0.06	0.53	10.26	5	6.79	0.85	43.76
60	6464	2	1	1	1	150.50	45.0	27.6	18.7	8.7	3.8	3.6	1.98	0.15	13	10.8	0.14	0.20	0.22	0.03	0.59	9.83	6	7.80	0.95	40.35
61	6465	2	1	1	1	163.43	37.8	32.5	17.3	12.4	3.8	3.6	2.00	0.16	13	12.1	0.10	0.14	0.22	0.06	0.52	10.19	5	8.50	0.82	54.62

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
62	6628	2	1	3	1	-	28.0	33.0	20.0	19.0	3.8	3.8	1.18	0.07	17	3.9	0.09	0.16	0.12	0.18	0.55	9.68	6	6.95	0.12	4.51
63	6629	2	1	3	2	-	29.0	29.0	26.0	16.0	4.0	3.8	0.56	0.04	14	5.9	0.04	0.12	0.09	0.18	0.43	10.19	4	6.92	0.32	4.12
64	6626	2	1	4	1	-	34.0	28.0	23.0	15.0	3.6	3.7	1.31	0.08	16	8.1	0.30	0.24	0.09	0.12	0.75	12.04	6	8.70	0.45	8.62
65	6627	2	1	4	2	-	32.0	26.0	26.0	16.0	3.9	3.8	0.47	0.04	12	7.2	0.26	0.15	0.07	0.18	0.66	10.24	6	8.10	0.06	3.32
66	6466	2	2	1	1	223.50	19.6	48.2	21.7	10.5	4.4	3.7	2.42	0.19	13	24.6	1.28	1.47	0.36	0.27	3.38	11.79	29	4.82	0.53	56.49
67	6467	2	2	1	1	168.96	16.4	49.3	20.2	14.1	4.5	3.8	2.57	0.23	11	30.7	0.15	2.01	0.52	0.11	2.79	14.01	20	5.55	0.56	52.76
68	6468	2	2	1	1	171.77	10.7	47.9	23.9	17.5	4.9	3.8	1.86	0.17	11	6.7	0.47	1.69	0.50	0.12	2.78	11.92	23	5.66	0.42	52.76
69	6469	2	2	1	1	205.26	12.3	52.3	23.7	11.7	4.5	3.8	1.47	0.16	9	3.9	0.28	1.64	0.25	0.11	2.28	10.87	21	5.41	0.45	38.49
70	6470	2	2	1	1	186.71	13.0	52.6	20.1	14.3	4.6	3.7	1.73	0.12	14	5.4	0.28	1.08	0.21	0.09	1.66	9.43	18	6.14	0.51	27.62
71	6632	2	2	3	1	-	37.0	27.0	21.0	15.0	4.1	3.8	1.03	0.08	13	6.7	0.60	1.33	0.19	0.15	2.27	11.67	19	4.88	0.21	10.22
72	6633	2	2	3	2	-	64.0	17.0	12.0	7.0	4.2	4.0	0.27	0.02	14	7.4	0.13	0.38	0.09	0.10	0.70	7.72	9	3.65	0.26	6.48
73	6630	2	2	4	1	-	12.0	47.0	22.0	19.0	3.8	3.6	2.31	0.12	19	8.9	0.30	1.22	0.23	0.18	1.93	14.07	14	6.99	0.43	4.80
74	6631	2	2	4	2	-	10.0	39.0	31.0	20.0	4.1	3.7	1.01	0.08	13	5.7	0.17	1.09	0.38	0.36	2.00	15.57	13	9.37	0.06	13.43
75	6373	2	3	1	1	171.37	33.2	33.5	18.6	14.7	3.7	3.7	1.76	0.19	9	6.7	0.16	0.18	0.16	0.02	0.52	10.42	5	8.05	0.96	45.94
76	6374	2	3	1	1	192.85	38.2	27.7	22.4	11.7	4.0	3.8	1.07	0.11	10	6.6	0.05	0.16	0.16	0.02	0.39	7.23	5	5.87	0.64	73.92
77	6375	2	3	1	1	164.11	21.4	42.5	22.2	13.9	3.6	3.6	2.35	0.21	11	17.5	0.21	0.19	0.07	0.02	0.49	11.99	4	10.21	0.98	35.38
78	6471	2	3	1	1	157.04	38.9	30.8	20.1	10.2	4.1	3.8	1.31	0.09	15	6.0	0.05	0.26	0.22	0.09	0.62	8.84	7	5.98	0.49	29.17
79	6472	2	3	1	1	205.76	52.6	25.3	14.6	7.5	4.3	3.9	0.98	0.10	10	3.1	0.19	0.28	0.14	0.09	0.70	8.26	8	5.06	0.42	36.93
80	6636	2	3	3	1	-	17.0	40.0	28.0	15.0	3.7	3.7	1.25	0.09	14	4.5	0.13	0.18	0.14	1.68	2.13	13.21	16	8.12	0.41	11.21
81	6637	2	3	3	2	-	20.0	36.0	29.0	15.0	4.1	3.8	0.93	0.08	12	4.5	0.44	0.34	0.16	0.18	1.12	13.09	9	7.47	0.14	7.24
82	6634	2	3	4	1	-	33.0	25.0	29.0	13.0	3.7	3.7	1.26	0.07	18	7.7	0.09	0.24	0.09	0.12	0.54	11.54	5	8.39	0.43	8.03

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
83	6635	2	3	4	2	-	31.0	22.0	34.0	13.0	4.2	3.8	0.62	0.03	21	5.2	0.04	0.03	0.05	0.12	0.24	12.28	2	7.81	0.14	3.06
84	6376	2	4	1	1	217.72	40.8	40.8	14.7	3.7	4.3	3.8	1.49	0.14	11	8.4	1.39	1.05	0.28	0.00	2.72	7.65	36	3.36	0.27	21.12
85	6377	2	4	1	1	181.92	39.7	33.3	19.7	7.3	3.9	3.7	1.48	0.15	10	13.9	0.16	0.10	0.14	0.02	0.42	9.98	4	7.32	0.68	53.86
86	6378	2	4	1	1	164.40	36.6	29.2	23.6	10.6	3.9	3.8	1.53	0.14	11	7.8	0.11	0.11	0.11	0.00	0.33	9.40	4	7.71	0.79	47.52
87	6379	2	4	1	1	157.47	45.8	37.8	9.2	7.2	3.7	3.6	2.70	0.23	12	23.1	0.16	0.21	0.29	0.02	0.68	12.21	6	7.98	0.60	48.05
88	6380	2	4	1	1	160.58	38.7	32.2	21.4	7.7	3.7	3.3	2.38	0.18	13	21.2	0.11	0.14	0.14	0.02	0.41	10.39	4	11.14	1.36	49.63
89	6648	2	4	3	1	-	37.0	23.0	29.0	11.0	4.1	3.8	0.73	0.06	12	8.6	0.17	0.06	0.19	0.12	0.54	9.56	6	6.17	0.36	17.80
90	6649	2	4	3	2	-	31.0	22.0	33.0	14.0	4.2	4.0	0.34	0.03	11	54.9	1.12	0.21	0.60	0.18	2.11	10.69	20	5.32	0.25	35.64
91	6646	2	4	4	1	-	34.0	31.0	20.0	15.0	3.7	3.6	0.90	0.05	18	10.1	0.04	0.06	0.09	0.06	0.25	12.43	2	10.23	0.75	9.04
92	6647	2	4	4	2	-	30.0	31.0	25.0	14.0	4.1	3.7	0.48	0.04	12	8.4	0.17	0.09	0.09	0.09	0.44	11.23	4	9.06	0.45	7.55
93	6442	3	1	1	1	160.75	18.4	54.6	14.8	12.2	4.8	4.5	2.34	0.19	12	22.1	3.68	1.84	0.65	0.27	6.44	8.96	72	0.52	0.13	46.24
94	6443	3	1	1	1	153.98	14.1	53.4	21.6	10.9	4.0	3.8	2.05	0.14	15	13.2	0.89	0.34	0.14	0.03	1.40	6.63	21	2.77	0.28	49.97
95	6444	3	1	1	1	136.45	13.5	48.2	25.9	12.4	4.1	3.7	4.27	0.23	19	15.7	1.45	0.49	0.14	0.09	2.17	9.45	23	3.87	0.29	49.35
96	6445	3	1	1	1	176.30	16.3	45.2	24.0	14.5	4.2	3.9	1.68	0.15	11	7.7	0.33	0.43	0.14	0.03	0.93	7.99	12	4.12	0.33	45.93
97	6446	3	1	1	1	209.10	25.3	49.7	18.0	7.0	4.6	3.9	1.24	0.09	14	11.8	1.72	0.56	0.14	0.09	2.51	6.23	40	2.72	0.16	38.17
98	6437	3	1	2	1	160.73	11.8	43.4	36.5	8.3	4.1	3.9	2.11	0.15	14	18.9	0.85	0.31	0.07	0.04	1.27	9.23	14	4.18	0.50	31.04
99	6438	3	1	2	1	179.03	9.6	43.7	34.1	12.6	4.7	4.1	1.18	0.09	13	4.1	0.14	0.15	0.07	0.03	0.39	6.61	6	3.15	0.31	32.28
100	6439	3	1	2	1	170.80	22.3	54.9	16.0	6.8	5.2	4.6	1.70	0.14	12	14.1	5.03	0.69	0.11	0.03	5.86	7.08	83	0.43	0.13	26.69
101	6440	3	1	2	1	184.76	12.8	43.4	33.0	10.8	4.7	4.1	0.99	0.08	12	3.7	0.90	0.00	0.07	0.06	1.03	6.83	15	3.04	0.18	32.59
102	6441	3	1	2	1	158.33	10.4	44.5	27.7	17.4	4.3	3.9	2.34	0.21	11	10.4	1.51	0.49	0.11	0.09	2.20	9.85	22	3.95	0.27	50.90
103	6433	3	1	3	1	-	21.8	51.7	18.1	8.4	5.2	4.2	2.03	0.15	14	7.5	4.50	1.62	0.14	0.03	6.29	8.51	74	0.56	0.19	49.04

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
104	6435	3	1	3	2	-	23.3	50.3	16.1	10.3	4.7	4.1	1.56	0.13	12	10.5	3.13	0.78	0.11	0.04	4.06	8.00	51	1.85	0.13	28.55
105	6434	3	1	4	1	-	11.3	44.4	24.9	19.4	4.1	4.0	2.06	0.18	11	6.2	0.19	0.25	0.11	0.06	0.61	11.84	5	6.03	0.40	40.35
106	6436	3	1	4	2	-	11.3	41.9	27.0	19.8	4.7	4.2	0.88	0.08	11	2.4	0.14	0.20	0.07	0.03	0.44	9.45	5	5.76	0.39	31.04
107	6423	3	2	1	1	181.35	11.9	39.6	29.0	19.5	4.3	3.9	1.87	0.17	11	4.1	0.33	0.14	0.11	0.03	0.61	11.35	5	4.48	0.41	48.05
108	6424	3	2	1	1	160.63	63.6	18.9	11.8	5.7	4.3	3.9	1.95	0.18	11	15.0	0.56	0.27	0.14	0.18	1.15	9.34	12	3.00	0.32	49.63
109	6425	3	2	1	1	154.86	11.8	41.7	27.1	19.4	4.1	3.9	2.33	0.16	15	6.3	0.38	0.22	0.13	0.03	0.76	12.20	6	4.03	0.33	18.48
110	6426	3	2	1	1	150.85	12.2	42.6	27.3	17.9	4.2	4.0	1.72	0.16	11	8.6	0.35	0.21	0.09	0.09	0.74	8.11	9	3.51	0.51	61.25
111	6427	3	2	1	1	125.16	12.1	39.6	28.8	19.5	4.2	3.9	2.98	0.18	17	3.6	0.53	0.44	0.13	0.10	1.20	10.46	11	3.84	0.41	54.38
112	6419	3	2	2	1	127.65	11.5	42.3	27.5	18.7	4.0	3.8	2.58	0.20	13	17.3	0.54	0.33	0.15	0.03	1.05	12.12	9	3.98	0.36	35.38
113	6420	3	2	2	1	177.15	10.9	40.6	28.1	20.4	4.4	4.0	1.68	0.10	17	11.2	0.38	0.13	0.09	0.03	0.63	9.18	7	3.52	0.32	21.12
114	6421	3	2	2	1	149.70	12.9	45.0	25.8	16.3	4.0	3.8	4.00	0.20	20	20.7	0.39	0.32	0.18	0.24	1.13	13.24	9	4.60	0.38	53.86
115	6422	3	2	2	1	215.43	14.6	42.8	32.6	10.0	5.1	4.1	0.28	0.02	14	1.4	0.70	0.25	0.13	0.07	1.15	6.24	18	2.80	0.20	47.52
116	6428	3	2	2	1	198.43	10.8	39.1	33.3	16.8	4.7	3.9	0.94	0.07	13	2.5	0.34	0.21	0.09	0.10	0.74	8.13	9	3.95	0.31	70.22
117	6429	3	2	3	1	-	23.8	44.7	18.6	12.9	4.4	4.0	1.66	0.13	13	4.1	0.47	0.38	0.26	0.05	1.16	6.96	17	2.82	0.36	32.21
118	6431	3	2	3	2	-	21.3	43.6	23.2	11.9	4.8	4.2	0.88	0.09	10	2.8	0.19	0.21	0.21	0.03	0.64	6.10	10	2.87	0.28	34.14
119	6430	3	2	4	1	-	8.9	46.5	26.5	18.1	4.0	3.8	1.65	0.13	13	3.0	0.33	0.16	0.11	0.10	0.70	7.87	9	3.51	0.45	62.30
120	6432	3	2	4	2	-	8.2	42.1	32.0	17.7	4.5	4.1	0.91	0.09	10	2.6	0.24	0.15	0.07	0.06	0.52	6.36	8	3.17	0.33	32.90
121	6329	3	3	1	1	160.58	20.2	40.9	19.5	19.4	3.8	3.8	2.51	0.19	13	10.0	0.44	0.27	0.18	0.02	0.91	10.07	9	6.32	0.39	42.83
122	6330	3	3	1	1	103.40	16.3	45.5	17.7	20.5	4.1	4.1	5.19	0.36	14	24.7	0.40	0.27	0.23	0.05	0.95	14.80	6	3.51	0.32	26.07
123	6331	3	3	1	1	156.21	15.3	43.4	20.1	21.2	3.9	3.9	2.89	0.16	18	5.4	0.26	0.19	0.13	0.02	0.60	8.93	7	5.19	0.19	55.25
124	6332	3	3	1	1	164.50	17.5	43.9	21.3	17.3	4.1	4.1	2.05	0.18	11	3.2	0.66	0.37	0.18	0.02	1.23	9.55	13	4.20	0.16	27.31

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
125	6333	3	3	1	1	132.44	21.2	43.4	18.2	17.2	3.9	3.9	2.44	0.19	13	7.8	0.31	0.29	0.18	0.04	0.82	9.45	9	4.61	0.42	68.28
126	6334	3	3	2	1	191.34	20.6	42.4	20.2	16.8	4.1	4.0	1.91	0.14	14	8.3	0.35	0.17	0.13	0.07	0.72	7.02	10	4.90	0.21	21.11
127	6335	3	3	2	1	175.61	19.2	47.0	17.5	16.3	4.0	3.9	2.43	0.20	12	5.6	0.30	0.37	0.18	0.04	0.89	9.70	9	3.82	0.35	15.52
128	6336	3	3	2	1	235.62	16.5	46.8	21.8	14.9	4.2	4.0	0.78	0.05	16	3.5	0.35	0.14	0.09	0.02	0.60	7.29	8	4.68	0.19	27.31
129	6337	3	3	2	1	207.62	21.2	43.8	19.3	15.7	4.5	4.1	1.31	0.09	15	3.2	1.27	0.45	0.18	0.04	1.94	7.56	26	3.80	0.02	29.80
130	6338	3	3	2	1	172.41	19.6	41.6	20.4	18.4	4.0	4.0	1.71	0.14	12	5.1	0.30	0.23	0.18	0.02	0.73	9.29	8	4.46	0.39	41.59
131	6339	3	3	3	1	-	20.8	44.0	21.6	13.6	4.0	4.0	1.84	0.12	15	18.3	0.36	0.40	0.18	0.02	0.96	6.88	14	3.25	0.36	86.90
132	6342	3	3	3	2	-	21.4	41.0	24.9	12.7	4.3	4.1	0.69	0.07	10	2.7	0.39	0.25	0.18	0.02	0.84	5.87	14	3.42	0.27	13.66
133	6340	3	3	4	2	-	18.7	39.2	22.5	19.6	4.1	4.0	0.91	0.08	11	11.3	0.39	0.22	0.11	0.04	0.76	7.86	10	4.49	0.34	13.04
134	6341	3	3	4	1	-	19.4	40.2	20.3	20.1	3.9	3.9	2.18	0.18	12	10.1	0.68	0.21	0.12	0.07	1.08	8.77	12	4.91	0.18	12.42
135	6447	3	4	1	1	170.43	18.4	44.9	20.8	15.9	4.1	3.8	1.89	0.15	13	7.5	0.23	0.23	0.14	0.09	0.69	9.29	7	5.33	0.53	33.52
136	6448	3	4	1	1	197.24	20.4	52.5	13.9	13.2	4.6	4.1	1.49	0.12	12	5.7	1.37	0.22	0.07	0.08	1.74	7.07	25	3.42	0.31	35.38
137	6449	3	4	1	1	203.03	27.0	53.6	9.8	9.6	4.0	3.8	1.99	0.16	12	11.1	0.56	0.46	0.14	0.09	1.25	7.25	17	3.27	0.33	28.55
138	6450	3	4	1	1	189.02	22.5	56.7	12.0	8.8	4.9	4.1	1.71	0.14	12	4.8	2.92	0.79	0.14	0.15	4.00	6.50	62	1.53	0.17	32.59
139	6451	3	4	1	1	201.43	20.2	52.1	12.6	15.1	4.8	4.0	2.51	0.18	14	5.7	8.19	0.91	0.27	0.09	9.46	12.96	73	1.93	0.13	36.31
140	6452	3	4	2	1	174.23	18.4	46.0	7.7	27.9	4.7	4.0	1.63	0.12	14	3.4	0.52	0.17	0.14	0.09	0.92	11.51	8	7.04	0.37	38.80
141	6453	3	4	2	1	198.30	16.5	48.6	22.0	12.9	4.8	4.1	1.42	0.11	13	6.9	3.58	0.58	0.22	0.06	4.44	12.70	35	5.84	0.29	37.86
142	6454	3	4	2	1	206.94	22.7	44.6	20.6	12.1	4.8	3.9	0.61	0.04	15	1.6	0.48	0.23	0.14	0.21	1.06	17.88	6	13.40	0.97	28.24
143	6455	3	4	2	1	202.94	21.1	50.6	18.8	9.5	4.5	3.9	0.97	0.06	16	2.6	0.79	0.20	0.14	0.06	1.19	11.69	10	8.70	0.95	35.38
144	6456	3	4	2	1	211.51	17.0	45.5	19.3	18.2	4.8	4.1	1.33	0.09	15	5.4	0.84	0.24	0.14	0.06	1.28	11.15	11	6.86	0.53	32.28
145	6457	3	4	3	1	-	17.6	45.5	21.5	15.4	4.5	3.9	1.85	0.15	12	13.4	0.14	0.28	0.16	0.09	0.67	10.37	6	5.60	0.58	32.59

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
146	6459	3	4	3	2	-	13.7	43.9	31.9	10.5	4.8	4.0	0.55	0.05	11	5.4	0.19	0.18	0.07	0.12	0.56	9.87	6	6.80	0.37	39.73
147	6458	3	4	4	1	-	10.1	46.5	24.7	18.7	4.3	3.7	1.91	0.20	10	7.9	0.24	0.39	0.36	0.09	1.08	18.66	6	14.02	1.78	34.14
148	6460	3	4	4	2	-	12.8	41.0	25.1	21.1	4.5	3.9	1.04	0.10	10	2.9	0.24	0.31	0.22	0.15	0.92	20.26	5	14.30	1.11	39.42
149	6409	4	1	1	1	133.91	30.9	9.7	22.6	36.8	4.4	3.8	1.62	0.17	10	1.4	0.39	0.16	0.09	0.10	0.74	26.61	3	20.23	1.02	26.40
150	6410	4	1	1	1	144.59	23.2	13.5	22.0	41.3	4.0	3.6	2.69	0.28	10	3.7	0.68	0.53	0.26	0.10	1.57	30.68	5	18.48	1.53	32.21
151	6411	4	1	1	1	163.12	18.5	14.8	25.6	41.1	4.4	3.7	2.66	0.25	11	1.7	0.34	0.26	0.22	0.10	0.92	31.83	3	20.42	1.79	38.02
152	6412	4	1	1	1	135.14	24.0	13.1	23.4	39.5	4.1	3.6	2.68	0.29	9	3.4	0.40	0.21	0.18	0.17	0.96	33.08	3	22.32	1.81	48.58
153	6413	4	1	1	1	154.07	42.8	17.7	13.9	25.6	3.9	3.6	3.12	0.26	12	6.8	0.34	0.19	0.13	0.17	0.83	22.50	4	16.98	1.68	43.30
154	6414	4	1	2	1	114.67	26.6	12.6	24.3	36.5	4.5	3.8	1.66	0.16	10	2.6	0.93	0.28	0.11	0.07	1.39	27.83	5	19.66	1.42	42.24
155	6415	4	1	2	1	136.49	31.7	15.5	19.9	32.9	4.1	3.5	3.47	0.31	11	8.7	0.35	0.25	0.18	0.03	0.81	28.39	3	18.19	1.57	32.74
156	6416	4	1	2	1	164.44	29.2	9.8	21.9	39.1	4.6	3.7	0.79	0.11	7	2.3	0.65	0.22	0.18	0.04	1.09	29.15	4	21.26	1.89	42.24
157	6417	4	1	2	1	151.48	32.7	14.6	17.5	35.2	4.3	3.7	2.11	0.19	11	8.5	0.34	0.21	0.13	0.10	0.78	26.31	3	18.28	0.98	45.94
158	6418	4	1	2	1	139.25	21.3	14.2	29.7	34.8	4.8	3.8	0.60	0.08	8	2.6	0.35	0.10	0.09	0.04	0.58	28.15	2	23.06	0.94	73.92
159	6405	4	1	3	1	-	24.9	10.0	28.2	36.9	4.4	3.7	1.80	0.21	9	1.4	0.59	0.30	0.18	0.10	1.17	27.39	4	18.59	1.68	54.91
160	6406	4	1	3	2	-	19.0	12.0	25.8	43.2	4.8	3.8	0.88	0.13	7	0.9	0.41	0.17	0.18	0.07	0.83	32.94	3	21.12	2.66	69.70
161	6407	4	1	4	1	-	56.1	18.7	11.6	13.6	4.4	3.6	1.55	0.12	13	5.0	0.38	0.14	0.15	0.17	0.84	10.72	8	8.46	0.83	27.46
162	6408	4	1	4	2	-	53.1	18.1	14.5	14.3	4.4	3.8	0.55	0.06	9	1.4	0.23	0.08	0.08	0.10	0.49	9.29	5	7.47	0.77	53.33
163	6315	4	2	1	1	214.02	77.4	14.8	4.3	3.5	3.7	3.7	0.72	0.05	14	5.0	0.47	0.14	0.11	0.07	0.79	3.37	23	3.07	0.10	25.45
164	6316	4	2	1	1	174.72	68.5	19.8	4.0	7.7	3.6	3.6	1.61	0.12	13	30.7	0.30	0.20	0.16	0.07	0.73	6.09	12	5.13	0.32	26.07
165	6317	4	2	1	1	229.08	68.8	18.9	5.7	6.6	3.8	3.7	1.30	0.09	14	5.0	0.17	0.15	0.15	0.07	0.54	5.57	10	4.28	0.33	27.31
166	6318	4	2	1	1	269.88	90.2	6.8	2.5	0.5	4.2	3.9	0.40	0.02	20	8.6	0.25	0.11	0.09	0.05	0.50	1.41	35	1.15	0.11	39.73

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
167	6319	4	2	1	1	240.16	74.2	5.9	14.5	5.4	4.0	3.9	0.63	0.05	13	4.0	0.21	0.14	0.09	0.05	0.49	4.04	12	3.70	0.22	44.07
168	6320	4	2	2	1	240.29	62.2	19.5	7.1	11.2	3.8	3.8	0.74	0.06	12	6.5	0.26	0.09	0.09	0.05	0.49	5.35	9	4.74	0.42	48.42
169	6321	4	2	2	1	254.14	50.4	24.9	12.6	12.1	4.0	3.8	0.72	0.07	10	5.8	0.60	0.18	0.11	0.07	0.96	7.17	13	5.96	0.46	58.35
170	6322	4	2	2	1	230.98	74.4	18.5	3.3	3.8	4.2	3.8	2.26	0.17	13	18.1	0.82	0.21	0.18	0.07	1.28	5.81	22	2.36	0.38	19.25
171	6323	4	2	2	1	231.31	64.9	21.5	6.1	7.5	4.1	3.8	1.23	0.10	12	8.4	1.33	0.26	0.11	0.02	1.72	5.23	33	3.20	0.30	54.62
172	6324	4	2	2	1	259.42	60.1	20.0	7.4	12.5	4.2	4.0	0.31	0.03	10	2.9	0.22	0.12	0.09	0.02	0.45	3.73	12	3.63	0.33	28.56
173	6325	4	2	3	1	-	69.4	20.7	5.1	4.8	4.2	3.9	0.82	0.06	14	6.3	0.55	0.23	0.09	0.02	0.89	3.60	25	2.90	0.22	30.42
174	6326	4	2	3	2	-	63.7	22.6	8.5	5.2	4.1	3.9	0.37	0.04	9	6.3	0.34	0.21	0.11	0.05	0.71	4.42	16	4.33	0.27	26.69
175	6327	4	2	4	1	-	75.0	15.2	3.5	6.3	4.1	3.9	1.53	0.11	14	16.5	0.26	0.22	0.11	0.05	0.64	6.14	10	4.20	0.54	16.76
176	6328	4	2	4	2	-	57.1	10.7	26.2	6.0	4.1	4.0	0.57	0.04	14	4.7	0.25	0.12	0.09	0.02	0.48	3.95	12	3.17	0.22	20.49
177	6363	4	3	1	1	175.37	63.1	22.6	7.3	7.0	4.1	3.8	1.92	0.11	17	12.8	0.10	0.06	0.07	0.03	0.26	5.91	4	4.53	0.44	27.46
178	6364	4	3	1	1	235.06	71.7	20.4	5.3	2.6	4.1	3.9	0.80	0.05	16	10.6	0.10	0.05	0.03	0.01	0.19	2.23	9	2.05	0.27	53.33
179	6365	4	3	1	1	148.00	36.0	16.9	20.0	27.1	4.3	3.7	3.09	0.28	11	12.6	0.25	0.17	0.17	0.09	0.68	18.84	4	12.88	1.18	26.40
180	6366	4	3	1	1	151.45	27.6	15.8	17.2	39.4	3.9	3.6	3.47	0.29	12	11.6	0.23	0.24	0.27	0.21	0.95	22.02	4	16.67	1.79	32.21
181	6367	4	3	1	1	148.01	41.2	18.0	12.1	28.7	3.9	3.8	3.46	0.26	13	10.6	0.17	0.13	0.08	0.10	0.48	21.02	2	11.97	0.87	38.02
182	6368	4	3	2	1	153.13	34.6	13.1	18.7	33.6	4.3	4.0	0.96	0.08	12	2.2	0.48	0.30	0.14	0.08	1.00	19.86	5	14.12	1.05	48.58
183	6369	4	3	2	1	122.81	31.2	12.4	19.3	37.1	3.8	3.8	1.73	0.18	10	2.8	0.16	0.11	0.07	0.02	0.36	21.81	2	14.91	1.09	43.30
184	6370	4	3	2	1	129.98	37.7	16.9	14.6	30.8	4.1	3.9	2.95	0.27	11	4.9	0.27	0.28	0.11	0.02	0.68	18.97	4	11.16	0.87	42.24
185	6371	4	3	2	1	203.80	42.4	17.3	11.9	28.4	4.2	3.9	1.59	0.15	11	2.5	0.11	0.10	0.07	0.02	0.30	15.16	2	10.74	1.10	32.74
186	6372	4	3	2	1	114.67	38.1	18.3	12.3	31.3	4.2	3.8	3.36	0.29	12	18.7	0.11	0.27	0.12	0.02	0.52	20.49	3	11.42	0.92	42.24
187	6359	4	3	3	1	-	48.9	20.0	9.3	21.8	4.2	4.1	1.97	0.17	12	5.3	0.11	0.21	0.14	0.08	0.54	12.54	4	8.33	0.23	76.03

Nr.	puslitnr	Landtype	replic.	samptype	layer	weight	sand	silt	clayk	clayh	phh	phk	C	N	C/N	P2O5	Ca	Mg	K	Na	Total	KTK	KB	Al	H	Fe
188	6360	4	3	3	2	-	46.7	19.6	14.1	19.6	4.1	4.0	1.06	0.11	10	3.0	0.10	0.16	0.07	0.03	0.36	11.87	3	11.69	0.48	45.41
189	6357	4	3	4	1	-	29.4	18.4	15.3	36.9	4.1	4.0	2.97	0.26	11	8.0	0.11	0.20	0.15	0.08	0.54	19.03	3	13.15	0.56	31.15
190	6358	4	3	4	2	-	30.5	12.5	19.7	37.3	4.2	4.1	1.66	0.15	11	3.8	0.12	0.13	0.08	0.09	0.42	18.53	2	12.85	0.31	77.62
191	6396	4	4	1	1	185.48	5.9	51.4	25.4	17.3	4.5	3.7	1.79	0.19	9	5.1	2.34	1.12	0.44	0.12	4.02	17.04	24	8.04	0.72	41.71
192	6397	4	4	1	1	187.67	5.4	60.8	13.7	20.1	3.8	3.6	2.84	0.24	12	2.5	0.29	0.55	0.17	0.10	1.11	14.18	8	6.89	0.76	43.82
193	6398	4	4	1	1	188.33	5.5	50.3	19.0	25.2	3.9	3.5	2.79	0.23	12	6.2	0.58	0.85	0.26	0.10	1.79	18.34	10	9.10	1.16	29.04
194	6399	4	4	1	1	200.98	3.9	52.1	24.8	19.2	4.1	3.5	2.07	0.17	12	1.1	0.52	0.71	0.19	0.07	1.49	16.47	9	9.85	0.92	54.38
195	6402	4	4	1	1	164.14	44.7	33.1	14.2	8.0	5.4	4.3	1.68	0.12	14	2.5	8.46	3.97	0.17	0.16	12.76	13.11	97	0.16	0.12	77.62
196	6393	4	4	2	1	230.74	7.7	42.9	27.0	22.4	4.7	3.8	0.78	0.10	8	1.7	0.81	0.92	0.22	0.10	2.05	11.78	17	8.14	0.67	35.90
197	6394	4	4	2	1	189.58	9.8	41.9	28.0	20.3	4.8	3.8	0.71	0.10	7	2.0	2.79	0.75	0.20	0.14	3.88	19.16	20	11.35	0.85	28.51
198	6395	4	4	2	1	152.86	20.7	24.5	24.5	30.3	4.0	3.5	1.72	0.19	9	2.9	1.92	0.92	0.18	0.11	3.13	40.98	8	30.78	2.28	32.74
199	6403	4	4	2	1	237.47	8.1	52.0	24.2	15.7	4.7	3.7	0.53	0.07	8	1.1	0.66	0.47	0.17	0.10	1.40	12.58	11	7.89	0.45	76.03
200	6404	4	4	2	1	264.10	38.3	35.5	18.0	8.2	4.7	3.8	0.51	0.08	6	3.6	0.95	0.93	0.22	0.15	2.25	15.38	15	9.47	0.79	45.41
201	6400	4	4	3	1	-	8.9	56.9	20.5	13.7	4.3	3.8	1.46	0.16	9	2.2	0.38	1.35	0.32	0.23	2.28	11.28	20	5.49	0.50	33.79
202	6401	4	4	3	2	-	8.3	55.1	26.9	9.7	4.9	3.8	0.80	0.10	8	1.1	0.38	1.42	0.35	0.07	2.22	12.56	18	6.73	0.60	31.15
203	6361	4	4	4	1	-	5.3	54.4	23.1	17.2	3.9	3.7	1.91	0.18	11	3.9	0.32	0.30	0.14	0.12	0.88	11.54	8	10.34	0.35	54.91
204	6362	4	4	4	2	-	13.1	45.1	27.6	14.2	4.1	3.8	0.52	0.08	7	2.2	0.26	0.53	0.14	0.06	0.99	13.76	7	11.83	0.98	69.70

note	***note***	***note***	***note***
1=log 30	Replication in each landtype.	1=non skid trail	1=0-20 cm
2=primary forest		2=skid trail	2=20-40 cm
3=log 10		3=profile downslope	

4=log 5	4=profile upslope

Appendix 10. Soil description in 16 1-ha plots in Primary (PF) and logged (LF) lowland forests in the Bulungan Reseacrh Forest-CIFOR, East Kalimantan.

Profile LF-30, plot 01/Upper Slope

Drainage: Quite Impeded

Soil Horizons	Description
Horizon 1:	0-4 cm; fibrious
Horizon 2:	4-14/16 cm; 10YR6/6; SCL/Sandy Clayey Loam; angular blocky, 1 cm, medium; friable; micro roots 25% macro roots 10%; micro pores +++, macro pores ++; sandstone 25%
Horizon 3:	14/16-33/36 cm; 10YR6/6; SCL/Sandy Clayey Loam; angular blocky, 1 cm, strong; firm; micro roots 15%, macro roots 7%; micro pores +++, macro pores ++; sandstone 20%
Horizon 4:	33/36-59/61 cm; 10YR6/6; SC/Sandy Clay; angular blocky, 1 cm, strong; firm; micro roots 25%, macro roots 3%; micro pores ++++, macro pores ++; mottle 2.5Y7/4
Horizon 5:	>59/61 cm; 7.5YR6/6; SC/Sandy Clay; angular blocky, 1 cm, strong; firm; micro roots 25%, macro roots 3%; micro pores ++++, macro pores +; mottle 2.5Y7/4 sandstone

Profile LF-30, plot 01/Down Slope

Drainage: Quick

Soil Horizons	Description
Horizon 1:	0-4/8 cm; 10YR6/4; mottle organic matter 50%; scl/sandy clayey loam; angular blocky, 0.5 cm, medium; friable; micro pores ++, macro pores ++; micro roots 40%, macro roots 5%
Horizon 2:	4/8-31/33 cm; 10YR6/6; mottle 2.5YR7/4 10%, organic matter 10%; sandy clayey loam; angular blocky, 2.5 cm, strong; firm; micro pores ++, macro pores ++; micro roots 15%, macro roots 15%
Horizon 3:	31/33-56/61 cm; 10YR6/6; mottle 7.5YR6/6 50%, organic matter 5%; sc/sandy clay; angular blocky, 1.5, strong; firm; micro pores +++, macro pores ++; micro roots 15%, macro roots 10%;
Horizon 4:	>56/61 cm; 7.5YR6/6; mottle 5YR6/6 and 2.5Y7/4 50%; cl/clayey loam; angular blocky, 1.5 cm, strong; firm; micro pores +++, macro pores ++; micro roots 15%, macro roots 5%; sandstone

Profile LF-30, plot 02/Upper Slope

Drainage: Quick
Note: Many hardpans in half-part of the profile below section

Soil Horizons	Description
Horizon 1:	0-3/6 cm; 10YR6/4; mottle of organic mater; sic/silt clay; hardpan 2.5YR4/4 2%; angular blocky, 0.5 cm, weak; friable; micro pores +++, macro pores ++; micro roots 30%, macro roots 10%
Horizon 2:	3/6-23/60 cm; 7.5YR6/6; mottle of organic matter; sic/silt clay; hardpan 5Y8/1 (light gray) and 2.5YR4/4 4%; angular blocky, 2 cm, strong; very firm; micro pores ++++, macro pores ++; micro roots 15%, macro roots15%
Horizon 3:	23/60-80/92 cm; 10YR6/6; sic/silt clay; hardpan 5Y8/1 60%and 2.5YR4/4 10%; angular blocky, 1.5 cm, medium; firm; micro pores ++++, macro pores +; micro roots 10%, macro roots 5%
Horizon 4:	>80/92 cm; 10YR6/6; sic/silt clay; hardpan 5Y8/1 85% and 2.5YR4/4 2%; angular blocky, 1 cm, weak; friable; micro pores ++++, macro pores +; micro roots 5%, macro roots 2%

Profile LF-30, plot 02/Down Slope

Drainage: Quick

Soil Horizons	Description
Horizon 1:	0-8/10 cm; 10YR5/3; mottle G25/5BG; sicl/silt clayey loam; angular blocky, 1 cm, medium; friable; micro pores ++++, macro pores +++; micro roots 50%, macro roots 7%
Horizon 2:	8/10-58/61 cm; 10YR6/4; mottle 2.5YR4/4 20%; sicl/silt clayey loam; angular blocky, 0.5 cm, weak; friable; micro pores +++, macro pores ++; micro roots 15%, macro roots 7%; pan of sand
Horizon 3:	58/61-83/85 cm; 10YR6/4; mottle 2.5YR4/4 5%; sicl/silt clayey loam; angular blocky, 0.5 cm, weak; friable; micro pores ++++, macro pores ++; micro roots 10%, macro roots 2%; pan 70%
Horizon 4:	>83/85 cm; 10YR6/4; pan of sand 95%; sicl/silt clayey loam; micro pores ++++, macro pores -; micro roots 5%, macro roots 2%

Profile LF-30, plot 03/Upper Slope

Drainage: Moderate
Dry leafs: 10cm thick

Soil Horizons	**Description**
Horizon 1:	0-4 cm; fibrist
Horizon 2:	4-15/19 cm; 10YR6/8; mottle of organic matter 10YR5/4; sc/sandy clay; angular blocky, 1 cm, weak; friable; micro pores +, macro pores +++; micro roots 30%, macro roots 25%
Horizon 3:	15/19-22/30 cm; 10YR6/8; sc/sandy clay; angular blocky, 1.5 cm, weak; friable; micro pores ++, macro pores ++; micro roots 30%, macro roots 15%;
Horizon 4:	22/30-40/49 cm; 10YR6/8; sc/sandy clay; angular blocky, 2 cm, strong; very firm; micro pores +++ macro pores +; micro roots 20%, macro roots 2%; quartz stone 0.5 cm 3%
Horizon 5:	>40/49 cm; 10YR6/8; c/clay; angular blocky, 2.5 cm, strong; very firm; micro pores ++++, macro pores +; micro roots 2%, macro roots 20%; quartz stone 3 cm and 0.5 cm 5%

Profile LF-30, plot 03/Down Slope

Drainage:

Soil Horizons	**Description**
Horizon 1:	0-4/8 cm; 10YR5/3; mottle 10YR6/6 and 10YR6/2 20%; sc/sandy clay; angular blocky, 1.5 cm, medium; friable; micro pores +++, macro pores +++; micro roots 60%, macro roots 15%
Horizon 2:	4/8-30/34 cm; 10YR6/6; mottle of organic matter; sc/sandy clay; angular blocky, 1.5 cm, medium; friable; micro pores +++, macro pores +++; micro roots 35%, macro roots 10%
Horizon 3:	30/34-61/69 cm; 10YR6/6; mottle of organic matter; sc/sandy clay; angular blocky, 1.5 cm, medium; friable; micro pores +++, macro pores ++; micro roots 25%, macro roots 5%; sandstone debris 2 cm 5%
Horizon 4:	61/69-100 cm; 10YR6/6; mottle 2.5YR4/4; sc/sandy clay; angular blocky, 2 cm, medium; friable; micro pores +++, macro pores ++;

	micro roots 5%, macro roots 5%; sandstone debris 5 cm 40%
Horizon 5:	>100 cm; 10YR6/6; mottle 2.5YR4/4 10%; sc/sandy clay; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro roots 5%, macro roots 10%; sandstone debris 10 cm 30% and quartz 10%

Profile LF-30, plot 04/Upper Slope

Drainage:

Soil Horizons	Description
Horizon 1:	0-2 cm; fibrist; micro roots 90%, macro roots 10%
Horizon 2:	2-7/10 cm; 10YR5/4; sl/sandy loam; angular blocky, 0.5, weak; very friable; micro pores +++, macro pores ++; micro roots 50%, macro roots 20%
Horizon 3:	7/10-24/27 cm; 10YR6/8; sl/sandy loam; angular blocky, 1 cm, weak; very friable; micro pores +++, macro pores ++; micro roots 40%, macro roots 10%
Horizon 4:	>24/27 cm; 10YR6/8; sl/sandy loam; angular blocky, 1 cm, weak; friable; micro pores +++, macro pores ++; micro roots 30%, macro roots-; sandstone 90%

Profile LF-30, plot 04/Down Slope

Drainage: Quick

Soil Horizons	Description
Horizon 1:	0-22/32 cm; 10YR6/6; mottle of sandstone 5Y8/2 2%; scl/sandy clayey loam; angular blocky, 1 cm, weak; friable; micro pores +++, macro pores +++; micro roots 15%, macro roots 7%
Horizon 2:	22/32-52/64 cm; 10YR7/6; mottle of organic matter 10YR5/4 2% and of sandstone 5Y8/2 2%; sc/sandy clay; angular blocky, 2.5 cm, strong; firm; micro pores ++++, macro pores ++; micro roots 10%, macro roots 3%
Horizon 3:	52/64-75/86 cm; 10YR6/6; mottle of organic matter 10YR5/4; scl/sandy clayey loam; angular blocky, 1 cm, weak; friable; micro pores +++, macro pores ++; micro roots 25%, macro roots 5%
Horizon 4:	>75/86 cm; 10YR6/6; mottle 2.5YR4/4; scl/sandy clayey loam; angular blocky, 1.5 cm, medium; firm; micro pores +++, micro roots 10%, macro roots -

Profile PF, plot 01/Upper Slope

Drainage: Impeded

Soil Horizons	Description
Horizon 1:	0-2/5 cm; fibric-hemic; micro roots 60%, macro roots 5%
Horizon 2:	2/5-13/15 cm; 10YR6/6; mottle of organic matter; cl/clayey loam; angular blocky, 1 cm, weak; friable; micro pores +++, macro pores ++; micro roots 20%, macro roots 10%
Horizon 3:	13/15-28/33 cm; 7.5YR6/6; c/clay; angular blocky, 1 cm, medium; friable; micro pores ++++, macro pores +; micro roots 15%, macro roots 10%
Horizon 4:	28/33-48/59 cm; 7.5YR6/8; c/clay; angular blocky, 1 cm, medium; firm; micro pores ++++, macro pores -; micro roots 10%, macro roots 5%
Horizon 5:	>48/59 cm; 5YR6/8; c/clay; angular blocky, 2 cm, medium; firm; micro pores ++++, macro pores -; micro roots 5%, macro roots 5%

Profile PF, plot 01/Down Slope

Drainage: Quite Impeded

Soil Horizons	Description
Horizon 1:	0-2/6 cm; fibrist; micro roots 80%, macro roots 3%
Horizon 2:	2/6-10/14 cm; 10YR5/4; sicl/silt clayey loam; angular blocky, 1.5 cm, weak; friable; micro pores +++, macro pores ++; micro roots 10%, macro roots 10%;
Horizon 3:	10/14-20/25 cm; 10YR6/6; cl/clayey loam; angular blocky, 1.5cm, medium; friable; micro pores +++, macro pores +; micro roots 10%, macro roots +
Horizon 4:	20/25-38/41 cm; 10YR6/6; cl/clayey loam; angular blocky, 1.5 cm, medium; firm; micro pores ++++, macro pores -; micro roots 10%, macro roots -; rayap
Horizon 5:	38/41-69 cm; 7.5YR6/8; c/clay; angular blocky, 3 cm, strong; very firm; micro pores ++++, macro -; micro roots 5%, macro roots -
Horizon 6:	>69 cm; 7.5YR6/8; c/clay; angular blocky, 3 cm, strong; very firm; micro pores ++++, macro pores -; micro roots 5%, macro roots -

Profile PF, plot 02/Upper Slope

Drainage: Quite Impeded

Soil Horizons	Description
Horizon 1:	0-4/14 cm; 10YR6/6; mottle of organic matter; cl/clayey loam; angular blocky, 1 cm, medium; friable; micro pores +++, macro pores ++; micro roots 20%, macro roots 5%;
Horizon 2:	4/14-16/26 cm; mottle 2.5Y7/4 and 7.5YR6/6; cl/clayey loam; 10YR6/6; angular blocky, 1.5 cm, medium; firm; micro pores +++, macro pores ++; micro roots 10%, macro roots 10%;
Horizon 3:	16/26-31/40 cm; 7.5YR6/6; mottle 2.5Y7/4 5% and 2.5YR4/6 5%;cl/clayey loam; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro roots 10%, macro roots 10%
Horizon 4:	31/40-55/75 cm; 5 YR6/6; mottle 2.5Y7/4 30% and 2.5YR4/6 30%; c/clay; angular blocky, 1.5 cm, medium; firm; micro pores ++++, macro pores +; micro roots 10%, macro roots 5%; hardpan
Horizon 5:	>55/75 cm; hardpan 2.5Y6/4 and 2.5YR4/6 100%

Profile PF, plot 02/Down Slope

Drainage: Quite Impeded

Soil Horizons	Description
Horizon 1:	0-4/8 cm; 10YR4/2 and 10YR5/4; cl/clayey loam; angular blocky, 1 cm, weak; friable; micro pores +++, macro pores ++; micro roots 40%, macro roots 30%; hardpan of limonit 5%
Horizon 2:	4/8-50/60 cm; 10YR6/6; cl/clayey loam; angular blocky, 1.5 cm, medium; friable; micro pores ++++, macro pores ++; micro roots 25%, macro roots 5%; hardpan of limonit 80%
Horizon 3:	50/60-70/90 cm; 10YR6/6; cl/clayey loam; angular blocky, 1.5 cm, medium; friable; micro pores ++++, macro pores +; micro roots 5%, macro roots 1%; hardpan of limonit 80%
Horizon 4:	>70/90 cm; 10YR6/6; cl/clayey loam; angular blocky, 1 cm, medium; friable; micro pores ++++, macro pores -; micro and macro roots -; hardpan of limonit 95%

Profile PF, plot 03/Upper Slope

Drainage: Impeded by clay

Soil Horizons	Description
Horizon 1:	0-2/4 cm; 10YR4/2; sic/silty clay; angular blocky, 0.5 cm, medium; friable; micro pores +, macro pores +++; micro roots 50%, macro roots 20%
Horizon 2:	2/4-23/26 cm; 10YR6/6; sic/silty clay; angular blocky, 1.5 cm, weak; friable; micro pores ++, macro pores ++; micro roots 15%, macro roots 15%; hardpan of limonit 80%
Horizon 3:	23/26-56/63 cm; 5YR6/8; c/clay; angular blocky, 1.5 cm, weak; friable; micro pores +++, macro pores +; micro roots 15%, macro roots 15%; charcoal
Horizon 4:	>56/63 cm; 5YR6/8; c/clay; angular blocky, 2 cm, medium; friable; micro pores +++, macro pores +; micro roots 5% and macro roots 5%

Profile PF, plot 03/Down Slope

Drainage: Impeded by clay and slope

Soil Horizons	Description
Horizon 1:	0-24/42 cm; 10YR7/6; rust 2.5Y3/1, 5Y7/3; sicl/silty clay loam; >5 cm, plastic; micro pores +++, macro pores +; micro roots 40%, macro roots 40%
Horizon 2:	24/42-80/98 cm; 10YR7/6; rust 2.5YR6/4;sic/silty clay; >5 cm, plastic; micro pores +++, macro pores +; micro roots 20%, macro roots 20%; hardpan of limonite, small
Horizon 3:	>80/98; 10YR7/6; 2.5YR4/4; sic/silty clay; >5 cm, plastic; micro pores ++++, macro pores -; micro roots 10%, macro roots -; limonite/gibbsite

Profile PF, plot 04/Upper Slope

Drainage: Slow by slope and clay

Soil Horizons	Description
Horizon 1:	0-3/5 cm; 10YR4/2; fibrist; micro roots 80%, macro roots 5%
Horizon 2:	3/5-17/25 cm; 10YR6/6; sic/silty clay; angular blocky, 1 cm, weak; very friable; micro pores ++, macro pores ++; micro roots 20%, macro roots 30%

Horizon 3:	17/25-33/36 cm; 7.5YR6/6; c/clay; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro roots 25%, macro roots 5%
Horizon 4:	>33/36 cm; 5YR6/8; c/clay; angular blocky, 2 cm, strong; very firm; micro pores +++, macro pores +; micro roots 10% and macro roots 5%

Profile PF, plot 04/Down Slope

Drainage: Quite Slow by clay

Soil Horizons	Description
Horizon 1:	0-5/8 cm; 10YR3/2; fibrist; micro roots 60%, macro roots 20%
Horizon 2:	5/8-15/23 cm; 10YR5/6; sic/silty clay; angular blocky, 0.5 cm, weak; very friable; micro pores +, macro pores +++; micro roots 30%, macro roots 40%
Horizon 3:	15/23-33/45 cm; 10YR6/6; rust 10YR6/2 rounded; sic/silty clay; angular blocky, 1 cm, medium; friable; micro pores ++, macro pores ++; micro roots 20%, macro roots 20%
Horizon 4:	33/45-62 cm; 7.5YR6/8; sic/silty clay; angular blocky, 2 cm, medium; quite plastic; micro pores ++, macro pores ++; micro roots 15% and macro roots 10%
Horizon 5:	>62 cm; 5YR6/8; rust 10YR7/6; c/clay; angular blocky, 2 cm, medium; friable; micro pores +++, macro pores +; micro root 5%, macro roots 3%

Profile LF-10, plot 01/Upper Slope

Drainage: Quite Impeded by clay

Soil Horizons	Description
Horizon 1:	0-6 cm; 10YR3/2; sicl/silty clay loam; angular blocky, 0.5 cm, medium; micro pores ++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	6-30/32 cm; 10YR4/6; sicl/silty clay loam; angular blocky, 1 cm, medium; friable; micro pores +++, macro pores +; micro roots +++%, macro roots +
Horizon 3:	30/32-60 cm; 10YR5/6; sicl/silty clay loam; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots +, macro roots +
Horizon 4:	>60 cm; 7.5YR6/6; sicl/silty clay loam; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots + and macro roots -

Profile LF-10, plot 01/Down Slope

Drainage: Impeded by stone

Soil Horizons	Description
Horizon 1:	0-20/26 cm; 10YR4/3; rust 10YR8/1; sicl/silty clay loam; angular blocky, 0.5 cm, weak; friable; micro pores +++, macro pores +; micro roots +++, macro roots +
Horizon 2:	20/26-30 cm; 10YR8/1; rust 10YR6/6; sicl/silty clay loam; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots ++, macro roots -
Horizon 3:	>30 stone

Profile LF-10, plot 02/Upper Slope

Drainage: Quite impeded by clay

Soil Horizons	Description
Horizon 1:	0-5/7 cm; 10YR3/2; sicl/silty clay loam; angular blocky, 0.3 cm, medium; friable; micro pores +, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	5/7-32/34 cm; 10YR5/6; sic/silty clay; angular blocky, 1 cm, medium;firm; micro pores ++, macro pores ++; micro roots ++, macro roots +
Horizon 3:	32/34-47/52 cm; 7.5YR5/6; rust 10YR5/6; sic/silty clay; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots +, macro roots +
Horizon 4:	>47/52 cm; 7.5YR5/6; sic/silty clay; angular blocky, 2 cm, strong; very firm; micro pores ++++, macro pores ; micro roots - and macro roots -

Profile LF-10, plot 02/Down Slope

Drainage: medium

Soil Horizons	Description
Horizon 1:	0-8/12 cm; 10YR4/6; sicl/silty clay loam; angular blocky, 0.3 cm, medium; friable; micro pores +, macro pores +++; micro roots +++, macro roots ++
Horizon 2:	8/12-30/40 cm; 10YR5/6; sicl/silty clay loam; angular blocky, 1 cm, medium; friable; micro pores ++, macro pores ++; micro roots ++, macro roots ++; black stone 20%
Horizon 3:	>30/40 cm; 7.5YR6/6; rust 10R6/8 15%; sic/silty clay; angular blocky, 2 cm, strong; firm; micro pores +++, macro pores +; micro roots ++, macro roots -

Profile LF-10, plot 03/Upper Slope

Drainage: medium

Soil Horizons	Description
Horizon 1:	0-6/9 cm; 10YR3/4; sicl/silty clay loam; angular blocky, 0.5 cm, medium; very friable; micro pores ++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	6/9-20/34 cm; 10YR5/6; sicl/silty clay loam; angular blocky, 1 cm, medium; friable; micro pores +++, macro pores +; micro roots ++, macro roots ++
Horizon 3:	20/34-45/50 cm; 10YR5/6; rust 7.5YR5/6 30%; sic/silty clay; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots ++, macro roots +
Horizon 4:	>45/50 cm; 10YR5/6; rust 7.5YR5/6 50%; sic/silty clay; angular blocky, 3 cm, strong; firm; micro pores ++++, macro pores -; micro roots ++ and macro roots -

Profile LF-10, plot 03/Down Slope

Drainage: medium

Soil Horizons	Description
Horizon 1:	0-3/5 cm; 10YR3/4; sicl/silty clay loam; angular blocky, 0.5 cm, medium; friable; micro pores ++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	3/5-14/40 cm; 10YR5/6; rust grey 20%; sicl/silty clay loam; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots ++, macro roots ++
Horizon 3:	14/40-67/72 cm; 10YR5/6; rust grey 30%; sic/silty clay; angular blocky, 1 cm, medium; firm; micro pores +++, macro pores +; micro roots +, macro roots +; stone 20 cm size
Horizon 4:	>67/72 cm; 7.5YR5/6; sic/silty clay; angular blocky, 3 cm, medium; firm; micro pores +++, macro pores -; micro roots + and macro roots -; stone

Profile LF-10, plot 04/Upper Slope

Drainage: Quite Slow by clay

Soil Horizons	Description
Horizon 1:	0-4/5 cm; 10YR3/4; sicl/silty clay loam; angular blocky, 0.5 cm, medium; very friable; micro pores ++, macro pores ++; micro roots +++, macro roots ++

Horizon 2:	4/5-14/20 cm; 10YR5/6; sicl/silty clay loam; angular blocky, 1 cm, medium; friable; micro pores +++, macro pores ++; micro roots ++, macro roots +
Horizon 3:	14/20-38/41 cm; 10YR5/6; sic/silty clay; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro roots ++, macro roots +
Horizon 4:	38/41-93 cm; 10YR5/6; rust 7.5YR6/8, 10%; c/clay; angular blocky, 3 cm, strong; firm; micro pores ++++, macro pores -; micro roots + and macro roots -; stone 10-20 cm
Horizon 5:	>93 cm; 7.5YR6/8; rust 10YR5/6, 10%; c/clay; angular blocky, 3 cm, strong; very firm; micro pores ++++, macro pores -; micro root +, macro roots -

Profile LF-10, plot 04/Down Slope

Drainage: Quite Slow by clay

Soil Horizons	**Description**
Horizon 1:	0-5/20 cm; 10YR3/4; rust 10YR5/6; sicl/silty clay loam; angular blocky, 0.5 cm, medium; very friable; micro pores ++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	5/20-32 cm; 10YR5/6; sicl/silty clay loam; angular blocky, 1 cm, medium; friable; micro pores +++, macro pores +; micro roots ++, macro roots +
Horizon 3:	32-49/60 cm; 10YR5/6; rust 10YR3/2, worm; sic/silty clay; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro roots +, macro roots +
Horizon 4:	>49/60 cm; 7.5YR6/8; rust 10YR5/6; sic/silty clay; angular blocky, 3 cm, medium; very firm; micro pores ++++, macro pores -; micro roots +, macro roots -

Profile LF-5, plot 01/Upper Slope

Drainage: Quite Impeded by slope

Soil Horizons	**Description**

Horizon 1:	0-4/8 cm; 10YR5/4; rust 10YR5/6 and 10R4/8 5% each; sil/silty loam; angular blocky, 1 cm, medium; firm; micro pores ++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	4/8-14/26 cm; 10YR6/6; rust 10YR5/6 30% and 10R4/8 15%; sicl/silty clay loam; angular blocky, 2 cm, strong; very firm; micro pores +++, macro pores ++; micro roots +++, macro roots ++
Horizon 3:	14/26-29/60 cm; 7.5YR6/6; rust 10YR5/6 50% and 10R4/8 15%; sicl/silty clay loam; angular blocky, 2 cm, strong; very firm; micro pores +++, macro pores +; micro roots +, macro roots +
Horizon 4:	>29/60 cm; 10YR5/6; rust 10R4/8; masive; micro pores ++++, macro pores -; micro roots + and macro roots -

Profile LF-5, plot 01/Down Slope

Drainage: Quick

Soil Horizons	Description
Horizon 1:	0-4/6 cm; 10YR4/3; sil/silty loam; angular blocky, 0.2 cm, weak; very friable; micro pores +, macro pores +++; micro roots +++, macro roots +++
Horizon 2:	4/6-7/14 cm; 10YR5/6; sicl/silty clay loam; angular blocky, 1 cm, strong; firm; micro pores +++, macro pores +; micro roots ++, macro roots ++
Horizon 3:	7/14-22/24 cm; 10YR5/6; rust 5YR6/8 and G27/1; sicl/silty clay loam; angular blocky, 2 cm, strong; very firm; micro pores +, macro pores +; micro roots +, macro roots +
Horizon 4:	>22/24 cm; G1,5; rust 10YR6/6; masive ; micro pores ++++, macro pores -; micro roots + and macro roots -

Profile LF-5, plot 02/Upper Slope

Drainage: Quite Slow by clay

Soil Horizons	Description
Horizon 1:	0-3/4 cm; 10YR3/2; ls/loamy sand; angular blocky, 0.5 cm, weak; very friable; micro pores ++, macro pores +++; micro roots ++, macro roots ++
Horizon 2:	3/4-18/22 cm; 10YR4/4; ls/loamy sand; angular blocky, 0.5 cm, weak; very friable; micro pores +++, macro pores ++; micro roots +++, macro roots ++; charcoal, 0.5 cm, 2%
Horizon 3:	18/22-37/49 cm; 10YR5/6; sl/sandy loam; angular blocky, 0.5 cm, weak; friable; micro pores +++, macro pores +; micro roots ++, macro roots ++; charcoal 0.5 cm, 20%
Horizon 4:	37/49-77/82 cm; 10YR5/6; sl/sandy loam; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro roots + and macro roots +; charcoal, 1 cm, 3%
Horizon 5:	>77/82 cm; 10YR7/6; sl/sandy loam; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores +; micro root +, macro roots +

Profile LF-5, plot 02/Down Slope

Drainage: Quite Impeded by slope

Soil Horizons	Description
Horizon 1:	0-6/20 cm; 10YR4/3; rust organic matter; ls/loamy sand; angular blocky, 1 cm, weak; not plastic; micro pores +++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	6/20-18/29 cm; 10YR6/6; rust G2,5/1, 1%; ls/loamy sand; angular blocky, 1 cm, weak; not plastic; micro pores +++, macro pores ++; micro roots ++, macro roots ++
Horizon 3:	18/29-32/36 cm; 10YR6/6; rust G2,5/1, 3%; sl/sandy loam; angular blocky, 2 cm, medium; plastic; micro pores +++, macro pores ++; micro roots ++, macro roots ++
Horizon 4:	38/41-39/70 cm; 10YR6/6; rust G2,5/1, 15%; sil/silty loam; angular blocky, 2 cm, medium; plastic; micro pores +++, macro pores ++; micro roots ++ and macro roots ++
Horizon 5:	39/70-71/99 cm; 10YR6/6; rust G2,5/1, 30%; sil/silty loam; angular blocky, 2 cm, medium; plastic; micro pores +++, macro

	pores +; micro root +, macro roots +
Horizon 6:	>71/99; G2,5/1; rust 10YR6/8, 30%; sl/sandy loam; angular blocky, 3 cm, strong; very plastic; micro pores ++++, macro pores -; micro roots +, macro roots -

Profile LF-5, plot 03/Upper Slope

Drainage: medium

Soil Horizons	**Description**
Horizon 1:	0-5 cm; 10YR4/3; sil/silty loam; angular blocky, 0.5 cm, medium; very friable; micro pores ++, macro pores ++; micro roots +++, macro roots ++
Horizon 2:	5-20 cm; 10YR6/6; sicl/silty clay loam; angular blocky, 0.5 cm, medium; friable; micro pores ++, macro pores ++; micro roots ++, macro roots ++
Horizon 3:	20-41 cm; 10YR6/8; sicl/silty clay loam; angular blocky, 2 cm, strong; firm; micro pores +++, macro pores -; micro roots +, macro roots +
Horizon 4:	>41 cm; 7.5YR6/8; sicl/silty clay loam; angular blocky, 3 cm, strong; very firm; micro pores +++, macro pores -; micro roots + and macro roots +

Profile LF-5, plot 03/Down Slope

Drainage: medium

Soil Horizons	**Description**
Horizon 1:	0-5/7 cm; 7.5YR4/3; sil/silty loam; angular blocky, 1 cm, medium; plastic; micro pores +, macro pores +++; micro roots +++, macro roots +++
Horizon 2:	5/7-30/33 cm; 7.5YR6/8; rust 7.5YR7/8 and 7.5YR8/1 5% each; sicl/silty clay loam; angular blocky, 2 cm, strong; very plastic; micro pores ++, macro pores ++; micro roots ++, macro roots ++
Horizon 3:	30/33-49/67 cm; 7.5YR7/8; 7.5YR8/1, 20%; sicl/silty clay loam; angular blocky, 3 cm, strong; very plastic; micro pores +++, macro pores +; micro roots +, macro roots ++; stone 10%
Horizon 4:	>49/67 cm; 7.5YR7/8; rust 7.5YR6/8, 10%; sicl/silty clay loam; angular blocky, 3 cm, strong; very plastic; micro pores +++, macro

	pores +; micro roots + and macro roots +; stone 10%

Profile LF-5, plot 04/Upper Slope

Drainage: medium

Soil Horizons	Description
Horizon 1:	0-5/8 cm; 10YR5/6; rust organic matter; sl/sandy loam; angular blocky, 1 cm, strong; friable; micro pores ++, macro pores +++; micro roots +++, macro roots ++
Horizon 2:	5/8-27/29 cm; 10YR6/8; scl/sandy clay loam; angular blocky, 2 cm, strong; friable; micro pores +++, macro pores ++; micro roots ++, macro roots +
Horizon 3:	27/29-49/52 cm; 10YR7/6; scl/sandy clay loam; angular blocky, 2 cm, strong; friable; micro pores +++, macro pores +; micro roots +, macro roots +
Horizon 4:	>49/52 cm; 10YR7/6; scl/sandy clay loam; angular blocky, 2 cm, strong; friable; micro pores +++, macro pores +; micro roots + and macro roots +; fragipan 10 cm, rounded

Profile LF-5, plot 04/Down Slope

Drainage: medium

Soil Horizons	Description
Horizon 1:	0-8/15 cm; 10YR5/4; sil/silty loam; angular blocky, 0.2 cm, weak; very friable; micro pores ++, macro pores +++; micro roots +++, macro roots ++
Horizon 2:	8/15-18/30 cm; 10YR6/6; rust 10YR5/4, 40%; sicl/silty clay loam; angular blocky, 2 cm, medium; firm; micro pores +++, macro pores ++; micro roots ++, macro roots +
Horizon 3:	18/30-56/74 cm; 7.5YR6/8; rust 10YR5/4, 10%; sicl/silty clay

	loam; angular blocky, 2 cm, strong; very firm; micro pores +++, macro pores +; micro roots +, macro roots +
Horizon 4:	>56/74 cm; 7.5YR6/8; rust 10YR6/68, 10%; sicl/silty clay loam; angular blocky, 3 cm, strong; very firm; micro pores ++++, macro pores -; micro roots + and macro roots -

Appendix 11. Indonesian Selective Cutting and Replanting (TPTI) system.
The following account provides an overview of the Silvicultural System of Indonesian Selective Cutting and Replanting (TPTI). Taken from: MoF. 1997.

1 Introduction

The Silvicultural of Indonesian Selective Cutting and Replanting (TPTI) is a silvicultural system which comprises logging practice with diameter limit and forest regeneration. In the beginning, it was referred to as Indonesian Selective Cutting (TPI) in the year 1972. This silvicultural system is considered the most appropriate in term of economy, ecology and technology to be used in tropical rain forest or other tropical forest in Indonesia. Natural production forests in Indonesia, either in the form of permanent or limited forest, are generally dominated by trees belonging to the Dipterocarpaceae, together with other commercial tree species. Several other tree species, sometimes dominate tropical rain forests which grow on certain sites, for example *ramin* in peat swamp forest, *Agathis* in forest with sandy soil ebony in rocky and somewhat dry areas, eucalypts in dry climate, *Rhizophora* in mangrove forest, *pelawan* in heath forest, etc.

The silvicultural system of selective cutting is one of the most difficult silvicultural system to be implemented, especially in the mixed forest of various ages, such as tropical rain forest in Indonesia. However, since the logged over area of selective cutting is opened and disturbed only a little as compared with that of clear cutting system, this system is consider safer for protection and sustainability of tropical rain forest ecosystem.

2 Silvicultural system of Indonesian selective cutting and replanting (TPTI)

Silvicultutral system is a series of planned activities to manage the forest which include logging, regeneration and tending of forest stand, to ensure the sustainability of timber production or other forest products. On the other hand, TPTI is a silvicultural system with diameter limit and forest regeneration.

TPTI system based on forest inventory and forest sustainability principle which include production sustainability, soil and water conservation, nature protection, silvical characteristic of the tree species and economic consideration of the company.

The objective of TPTI system is regulating the utilization of natural production forest and improving the value of forest, in terms of quality in the logged over areas, in order that in the next rotation, mixed forest stand can be formed which can function as sustainable raw material supplier for industry.

For achieving the above mentioned objective, silvicultural practice in forest regeneration is directed towards :

- Regulating the composition of tree species in the forest so that it will be more profitable in terms of ecology and economy.
- Regulating the structure and maintaining the optimum density of the forest which is expected to increase the production of round wood as compared to the previous condition.
- Ensuring the forest function for soil and water conservation.
- Ensuring the function of forest protection.

Selective cutting system is in fact more difficult than order silvicultural system, and require forester professionalism. In contrast with the previous TPI, in the present TPTI, each HPH (forest concession) is obliged to establish a department of silviculture separated with department of exploitation or logging. The department of silviculture should be sufficiently supplied with facilities, fund and infrastructure, and should be led and staffed by forestry educated personnel who understand the science and practice of silviculture.

All activities and schedules in TPTI should be understood and implemented. Establishment of TPTI demonstration plots, seed stand and nurseries spread over the logged over area, will support very much the success of TPTI. Therefore, each of silviculture staff in HPH will find it easy to refer to the desirable condition according to TPTI technical guidelines.

3 Series of activities

To achieve the target expected in TPTI, the following series of activities and schedules are establish :

No.	Stage of TPTI Activities	Time of Implementation (Year)
1.	Organization of Working Area	Et-3
2.	Stand Inventory before Logging	Et-2
3.	Opening Up of Forest Area	Et-1
4.	Logging	Et 0
5.	Liberation	Et+1
6.	Inventory of Residual Stand	Et+1
7.	Procurement of Planting Stock	Et+2
8.	Enrichment/Planting	Et+2
9.	First Stage Tending	Et+3
10.	Advanced Tending	
	Liberation	Et+4
	Thinning	Et+9
		Et+14
		Et+19
11.	Forest Protection and Research	Continually

Note Et : denotes the year when the logging takes places

4 General provision

The implementation of TPTI silviculture system in forest utilization is intended to regulate the cutting and silviculture of natural production forest, which has a minimum number of 25 nucleus trees (seed trees) per hectare. The appointed nucleus or seed trees are preferred as those commercial trees similar with the ones logged, with minimum diameter of 20 cm. If the number is less than 25 trees per hectare, other species can be included.

Annual cutting quota is adjusted with the cutting quota and the standing stock volume of commercial species.

Forest concession holders should prepare :

- Unit of silviculture organization which is separated from logging organization.
- Sufficient skillful forestry technical personnel.
- Sufficient budget for silviculture activities.

In a unit of natural production forest utilization which has a specific stand structure and species composition, an adjustment of TPTI silvicultural system can be made as follows :

In mangrove forest, the silvicultural system guidelines is based on the Decree of Director General of Forestry No : 60/Kpts/DJ/1/1978.

In swamp forest with forest composition comprising specific commercial species, for instance *ramin, perupuk,* and other commercial species, and the forest concession holders are not able/difficult to conduct planting/enrichment, then the concession holder is allowed only to cut trees maximally 2/3 of the total number of trees according to the species composition.

In swamp forest, in which trees with diameter of 50 cm upward are not found, for instance in mixed *ramin* forest, then for specifically *ramin* forest, reduction of diameter limit to 35 cm. For cutting can be done, with nucleus (seed tree) is minimally 25 trees per hectare. Cutting rotation is established as 25 years. Regulation of trees which are allowed to be cut, follows a provisions as in point (b).

In condition where the nucleus trees with diameter of 20 – 49 cm is less than 25 trees per hectare, then the lack of this tree can be compensated by adding with other commercial species with a diameter of more than 50 cm which function also as seed trees. Minimum diameter limit of trees to be cut is 50 cm, with minimum number of nucleus trees at 25 trees per hectare, and the cutting rotation is 35 years.

In conditions where some commercial species grow very slowly, and commercial tree species with a diameter of 50 cm upward is difficult to find, such as in mixed ebony forest, then specifically for ebony forest, reduction of diameter limits to 35 cm for cutting is allowed, with a minimum number of nucleus trees 23 trees per hectare (with a minimum diameter of 15 cm). Cutting rotation is established as 45 years.

Appendix 12. Lianas found in PF, LF-5, LF-10 and LF-30 in the Bulungan Research Forest, East Kalimantan

Family	Species Name	Group	PF	LF-5	LF-10	LF-30	Total
Acanthaceae	*Thunbergia sp.*	Liana			30		30
Anonaceae	*Artabotrys sp.*	Liana	3	413	39	21	476
	Artabotrys sp.1	Liana			1		1
	Artabotrys suaveolens (Blume) Blume	Liana	9				9
	Desmos chinensis Lour.	Liana	22				22
	Desmos sp.	Liana			3	3	6
	Fissistigma manubriatum (Hook.f. & Thomson) Merr.	Liana	10		1		11
	Fissistigma sp.	Liana				1	1
	Friesodielsia borneensis (Miq.) van Steenis	Liana	10		4		14
	Friesodielsia excisa (Miq.) van Steenis	Liana	8				8
	Friesodielsia sp.	Liana	10		29	44	83
	Friesodielsia sp.1	Liana				2	2
	Friesodielsia sp.2	Liana				1	1
	Miliusa sp.	Liana			6		6
	Mitrelea sp.	Liana				10	10
	Neo-uvaria	Liana				4	4
	Uvaria borneensis (Merr.) T.M.A.Utterige	Liana			4		4
	Uvaria sp.	Liana	10	18	25	58	111
	Uvaria sp.1	Liana				15	15
	Uvaria sp.2	Liana				1	1
	Uvaria sp.3	Liana				7	7
	Uvaria sp.4	Liana				10	10
Apocynaceae	*Willughbeia coriacea Wall.*	Liana	58		33		91
	Willughbeia firma	Liana	15				15
	Willughbeia sp.	Liana	19				19
	Willughbeia sp.1	Liana	22			207	229
	Willughbeia sp.2	Liana	32			39	71
	Willughbeia sp.3	Liana				26	26
	Willughbeia sp.4	Liana	4				4
Araceae	*Photos sp.*	Liana	3		8	6	17
	Photos sp.1	Liana	13				13
	Photos sp.2	Liana	1				1
	Photos sp.3	Liana	1				1
	Raphidophora sp.	Liana	3	12			15
	Schindapsus sp.	Liana			198		198
	Scindapsus sp.	Liana	12	209	214	101	536
	Scindapsus sp.1	Liana				4	4
	Scindapsus sp.2	Liana				5	5
Asclepiadaceae	*Hoya sp.*	Liana	1				1
Capparaceae	*Capparis sp.*	Liana	3	3			6
	Salacia leucoclada Ridl.	Liana	3				3
	Salacia sp.	Liana	1		33	39	73
Combretaceae	*Combretum nigrescens King*	Liana	1		31	11	43

	Combretum sp.	Liana	1			33	34
	Combretum sp.1	Liana				5	5
Connaracae	*Agelaea borneensis Merril*	Liana			63	7	70
	Agelaea trinervis Merrill	Liana	50	18	65	41	174
	Cnestis platantha Griff	Liana	4			1	5
	Cnestis sp.	Liana				15	15
	Connarus sp.	Liana	1	223	96		320
	Connarus semidecandrus Jack	Liana	412		21	1717	2150
	Connarus sp.1	Liana				60	60
	Connarus sp.2	Liana				1	1
	Rourea sp.	Liana	2				2
	Rourea sp.1	Liana	3				3
Convolvulaceae	*Erycibe sp.*	Liana	33		21	35	89
	Erycibe sp.1	Liana	3			5	8
	Erycibe sp.2	Liana	4				4
	Erycibe sp.3	Liana				1	1
	Erycibe sp.4	Liana	3			22	25
	Merremia sp.	Liana			9		9
Cucurbitaceae	*Cucurbitaceae*	Liana				12	12
	Trichosanthes sp.	Liana				1	1
Euphorbiaceae	*Omphalea bracteata (Blanco) Merr.*	Liana			15	111	126
Flagelariacea	*Flagellaria sp.*	Liana				2	2
Gesneriaceae	*Aechynanthus sp.*	Liana	2				2
Gnetaceae	*Gnetum sp.*	Liana	2	5	5	122	134
Icacinaceae	*Maesa sp.*	Liana				33	33
	Phytocrene sp.	Liana	12				12
	Phytocrene sp.1	Liana	1				1
Leguminosae	*Bauhinia kockiana Korth.*	Liana	30				30
	Bauhinia semibifida Roxb.	Liana	14				14
	Bauhinia sp.	Liana	1		167	53	221
	Bouchinia sp.	Liana		70			70
	Mucuna sp.	Liana				4	4
	Phanera sp.	Liana	2				2
	Spatholobus ferrugineus Benth.	Liana	77		181	45	303
	Spatholobus hirsutus H.Wiriadinata & J.W.A.Ridder-Numan	Liana	36				36
	Spatholobus litoralis Hassk.	Liana	110		125		235
	Spatholobus macropterus Miq.	Liana	177				177
	Spatholobus sanguineus Elmer	Liana	116				116
	Spatholobus sp.	Liana	2		7	7	16
	Spatholobus sp.1	Liana	143			89	232
	Spatholobus sp.2	Liana	628			290	918
	Spatholobus sp.3	Liana	1			28	29
	Spatholobus sp.4	Liana				285	285
	Spatholobus sp.5	Liana	102				102
Liliaceae	*Smilax sp.*	Liana	7	5	7	1	20
	Smilax Zeylanica	Liana		8			8
Linaceae	*Indraroucrea sp.*	Liana			3		3
Loganiaceae	*Strychnos sp.*	Liana	10		18	302	330
	Strychnos sp.1	Liana				1	1
Menispermaceae	*Anamirta cocculus Wigght & Arn*	Liana			1		1
	Coscinium sp.	Liana			1		1
	Fibraurea ochroleuca	Liana				50	50
	Fibraurea sp.	Liana				2	2
	Fibraurea tinctoria Lour.	Liana	8				8
	Menispermaceae	Liana		17	17	11	45
	Menis sp.2	Liana				7	7
	Menisp. 1	Liana				17	17

	Stephania corymbosa	Liana			1		1
	Tinospora sp.	Liana			1		1
Myrsinaceae	*Embelia sp.*	Liana	2		1		3
Palmae	*Calamus blumei Becc.*	Liana	30	10	10		50
	Calamus caesius	Liana				8	8
	Calamus flabellatus Becc.	Liana	15			1	16
	Calamus javensis Blume	Liana	4		10		14
	Calamus sp.	Liana		172	74	66	312
	Calamus sp.1	Liana	3				3
	Calamus sp.2	Liana	7		1	1	9
	Calamus tiliaris	Liana		1			1
	Caryota sp.	Liana			5	10	15
	Ceratolobus sp.	Liana	1				1
	Daemonorops sabut Becc.	Liana	15	9	19	24	67
	Daemonorops sp.	Liana	18	330	116	95	559
	Korthalsia echinometra Becc.	Liana	6	53	26	56	141
	Korthalsia ferox Becc.	Liana	45			5	50
	Korthalsia furtadoana J.Dransf.	Liana	13			9	22
	Korthalsia sp.	Liana	2	69	51	17	139
	Korthalsia sp.1	Liana			7		7
	Korthalsia sp.2	Liana				2	2
Pandanaceae	*Freycinetia sp.*	Liana	9	21	2	3	35
Passifloraceae	*Adenia macrophylla Blume Kord.*	Liana			1		1
Piperaceae	*Piper baccatum Blume*	Liana	1				1
	Piper sp.	Liana		71	40	6	117
	Piper sp.1	Liana				1	1
	Piper sp.2	Liana				1	1
Rhamnaceae	*Ventilago sp.*	Liana	113	24	136	323	596
	Ziziphus horsfieldii	Liana	1				1
	Ziziphus liana	Liana				1	1
	Ziziphus sp.	Liana		72	28	14	114
	Ziziphus sp.1	Liana			19	4	23
	Ziziphus sp.2	Liana			2		2
	Ziziphus sp.3	Liana				5	5
	Ziziphus sp.4	Liana				8	8
Rosaceae	*Rubus moluccana*	Liana			1		1
	Psychotria sarmentosa Blume	Liana	2				2
	Uncaria hirsuta	Liana	1				1
	Uncaria hirta	Liana	1				1
	Uncaria littorale	Liana	1				1
	Uncaria longifolia (Poir.) Merr.	Liana			38		38
	Uncaria sp.	Liana	1	24	19	11	55
	Uncaria sp.1	Liana		3	3		6
	Uncaria sp.2	Liana			13		13
	Uncaria sp.3	Liana				1	1
Rubiacea	*Paederia foetida L.*	Liana	6				6
Rutaceae	*Luvunga sp.*	Liana	10	24	46	170	250
	Luvunga sp.1	Liana	20				20
	Luvunga sp.2	Liana	1				1
Sterculiaceae	*Buettneria sp.*	Liana			2	1	3
Thymelaeaceae	*Enkleia malaccensis Griff.*	Liana	9	1	2	48	60
	Enkleia sp.	Liana		9			9
Vitaceae	*Ampelocissus Borneensis*	Liana	2				2
	Ampelocissus imperialis	Liana			1	6	7
	Ampelocissus sp.	Liana	13				13
	Cayratia sp.	Liana				2	2
	Cayratia sp.1	Liana	77				77
	Cayratia sp.2	Liana	1				1

Cissus sp.	Liana	2		5		7
Pterisanthes sp.	Liana			6		6
Pterisanthes sp.1	Liana				1	1
Tetrastigma manubriatum	Liana				5	5
Tetrastigma sp.	Liana	1	7	12	7	27
Tetrastigma sp.1	Liana				1	1
Vitaceae sp.	Liana				1	1
Vitaceae sp.1	Liana				1	1
Vitis sp.	Liana		6	4		10
Number of lianas including rattan (Palmae)		2704	1907	2183	4946	11740