14
Illipe Nuts (*Shorea* spp.) in West Kalimantan: Use, Ecology, and Management Potential of an Important Forest Resource*

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Introduction

THE term *illipe* is originally a Tamil word used to describe the oil seeds produced by *Bassia* and other Sapotaceous trees in southern India (Burkhill, 1935). In current usage, however, this name has come to refer almost exclusively to the shelled and dried seeds of certain dipterocarp trees from the genus *Shorea* which grow in Borneo, Peninsular Malaysia, Sumatra, the Moluccas, and the Philippines. The seeds from these *Shorea* trees contain an edible oil whose physical and chemical properties are remarkably similar to cocoa butter.[1] Bornean illipe nuts are collected locally for subsistence use as a flavouring, cooking oil, or medicinal salve, and large quantities are also harvested and sold internationally to be used in the manufacture of chocolate, soap, candles, and cosmetics. In 1987 alone, almost 14,000 tons of illipe nuts with an estimated market value of over US$5 million were exported from West Kalimantan (Indonesia, Biro Pusat Statistik, 1987).

In spite of their obvious economic importance, very little has been written about the illipe nuts of Borneo; detailed studies from West Kalimantan are especially scarce. The purpose of the present report, therefore, is to provide a brief overview of the illipe nut trade in West Kalimantan, to characterize the distribution and abundance of the resource base that supports this trade, and to outline the current constraints

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to increased utilization. The preliminary results from an ecological study of one *Shorea* species are then presented to illustrate the great potential for managing natural populations of illipe nut in West Kalimantan.

Economic Importance of Illipe Nuts

The following discussions are based on the results of a two-year study (1990–2) of the botany, use, and marketing of illipe nuts in West Kalimantan. Field research and interviews were conducted primarily in the districts of Pontianak, Sambas, and Sanggau in the northern region of the province.

Species Used

At least 20 different species of illipe nut or *tengkawang* are native to West Kalimantan (Soewanda, Prawira and Sutisna, 1978). The most common or commercially important of these species are listed in Table 14.1 together with information about local nomenclature and habitat. It should be noted that there is little standardization in local nomenclature and the same species is frequently described using different common names from one village to the next. This situation is especially confusing in regard to *tengkawang tungkul*, which may be *S. macrophylla*, *S. stenoptera* or, in many cases, an undescribed hybrid of these two species (Ashton, 1982). Illipe nut trees occur in a wide variety of different forest habitats, but appear to exhibit a marked preference for alluvial soils along river banks and steep clay ridges at elevations of less than 800 metres.

Although the seeds of all the *Shorea* species listed in Table 14.1 possess three long and two short 'wings' (calyx lobes), there is considerable variation between species in terms of seed size, morphology, and oil content. The average weight of fresh seeds ranges from about 40 to 50 grams for *S. macrophylla* to less than 5 grams for *S. seminis*; the calyx lobes of *S. seminis* are scarcely 1.5 centimetres long, while those of *S. pinanga* can extend out to 30 centimetres. The few chemical analyses that have been conducted on illipe nuts from West Kalimantan (Sumadiwangsa and Silitonga, 1974; Wong, 1988) suggest that the oil content of most species averages about 50 per cent. Connell (1968), however, reports that the oil content of *S. seminis* seeds from Sarawak can be as high as 61.8 per cent. This finding is supported by the observations of local collectors in Kalimantan who also report that the smaller illipe nuts contain the largest quantity of oil.

The larger illipe nuts, e.g. *S. macrophylla*, *S. stenoptera* and *S. splendida*, are the most heavily exploited in West Kalimantan. This pattern may indicate that there is a greater abundance of these species, or, conversely, that it is simply faster and easier to collect a kilogram of material if each seed is of relatively large size. Most bulk collections, however, are taxonomically diverse and contain a mixture of both large and small seeds.

TABLE 14.1
Nomenclature and Habitat of Common Illipe Nut Species in West Kalimantan

Scientific Name	*Local Name*	*Habitat*
Shorea amplexicaulis Ashton	*Tengkawang telur* *Tengkawang rambai*	Common on clay soils; especially ridges
Shorea atrinervosa Sym.	*Tengkawang nyamuk* *Tengkawang bukit*	Steep hillsides on clay soils; locally abundant
Shorea beccariana Burck	*Tengkawang rambai* *Tengkawang bukit*	Clay ridges and steep hillsides
Shorea macrophylla (De Vriese) Ashton	*Tengkawang tungkul*	Deep clay alluvium and riverbanks
Shorea mecistopteryx Ridl.	*Tengkawang layar*	Sandy clay soils on low hills
Shorea palembanica Miq.	*Tengkawang majau*	Clay-rich alluvium in lowlands
Shorea pinanga Scheff.	*Tengkawang telur* *Tengkawang layar*	Steep ridges at medium elevation; locally common
Shorea seminis (De Vriese) Sloot	*Tengkawang terindak*	Riparian sites on clay soils
Shorea splendida (De Vriese) Ashton	*Tengkawang rambai*	Clay-rich alluvium in lowlands
Shorea stenoptera Burck	*Tengkawang tungkul* *Tengkawang rambai*	Poorly drained sandy soils on low terraces; groundwater podzols in heath forest

Source: Habitat designations based on Soewanda, Prawira, and Tantra (1976), Ashton (1982), and personal observations.

Collection and Processing

The collection and preliminary processing of illipe nuts in West Kalimantan is similar to that reported from other regions (Anderson, 1975; Chin, 1985). After fruitfall, the seeds are collected from the ground and de-winged, de-husked, and dried in the sun for a week to 10 days. It is important that the illipe nuts be collected before they germinate because the young shoots rapidly metabolize the oil reserve in the seed for growth. Controlled laboratory studies have shown that a germinated seed may contain less than half of the oil of a fresh one (Connell, 1968). Unfortunately, it is extremely difficult to tell whether a seed has germinated after it is dried, and spent cotyledons are occasionally collected and mixed in with commercial shipments to increase the weight. In some regions, the de-winged seeds are soaked in water for a week or so prior to drying to facilitate the separation of the husk from the seed and to kill off any insect pests. The inherent problem with this method is that immersion frequently triggers the germination of *Shorea* seeds.

If the illipe nuts have been collected for household use, a simple process of slow heating and pressure is used to express the oil from the dried seeds. The warm oil is decanted into bamboo tubes where it later solidifies. This illipe nut 'butter' can then be pushed from the tube as needed and spread over hot rice as a flavouring agent, used as a cooking oil, or rubbed on chapped lips and skin abrasions. The great majority of the illipe nuts currently collected in West Kalimantan, however, are sold to government co-operatives (*kooperasi unit desa*) or independent middlemen who transport them to the C.V. Mentawi processing plant in Pontianak. Upon arrival at the plant, the seeds are immediately re-dried to a moisture content of 7 per cent to avoid spoilage and a sophisticated system of steam cooking, pressing, and hexane extraction is used to extract the oil. Wong (1988) provides a detailed, although somewhat technical, description of the mechanics of this extraction process.

Cultivation

Most of the published information on illipe nuts would lead one to believe that the seeds are harvested almost exclusively from wild, forest trees (see Anderson, 1975; Salleh, 1987; DeBeer and McDermott, 1989; Menon, 1989). Although some wild trees are undoubtedly exploited for seeds, a large percentage of the illipe nuts collected in West Kalimantan come from trees which have been cultivated or deliberately managed. Rural populations plant *Shorea* trees in house gardens, swidden fallows, and forest orchards (*tembawang*), and judging from the size of some of these trees, it is apparent that this practice has been occurring for several hundred years. The illipe nut trees are usually mixed with a variety of other useful species such as durian (*Durio zibethinus*), rambutan (*Nephelium* spp.), cempedak (*Artocarpus integer*), jelutong (*Palaquium* spp.), *belian* or ironwood (*Eusideroxylon zwageri*), and *arenga* palm (*Arenga pinnata*). Some forest orchards may contain as many as nine different species of illipe nuts.

Traditional practice of planting illipe nut trees in house gardens has had a major impact on the current distribution of *Shorea* species in West Kalimantan. Many of the dense groves of illipe nut trees encountered in remote and seemingly undisturbed forest areas in Borneo are actually the remains of old longhouse sites. The fact that several of the more valuable species such as *S. macrophylla*, *S. seminis*, and *S. palembanica* have been reported to have an affinity for alluvial soils along river banks (Browne, 1955; Wood and Meijer, 1964; Ashton, 1982) may also, in large part, be attributable to the desirability of these habitats as human dwelling sites. Illipe nuts have been traded commercially in West Kalimantan at least since the middle of the eighteenth century (Wong, 1988). The cultivation and management of these trees has been so extensive and has occurred over such a long period of time that it is very difficult to distinguish between what is wild and what was originally planted or selectively favoured.

There are very few large-scale, commercial plantations of illipe nut in West Kalimantan. Two plantations, each approximately 100 hectares, exist near the town of Ngabang in the Sanggau district, and a third has been established in the Pontianak district near Mandor. The Ngabang plantations, one of *S. macrophylla* and the other a mixture of *S. splendida*, *S. pinanga*, and *S. macrophylla*, are estimated to be well over 100 years old. The Mandor plantation is planted with a local variety of *S. stenoptera* (*S. stenoptera* forma Burck) that reportedly fruits every year and starts to flower at a very early age (Anderson, 1975). Several authors have recommended that the area of illipe nut plantations in West Kalimantan be greatly increased (for example Wong, 1988; Menon, 1989). With this objective in mind, a detailed study was conducted by the Forest Products Institute at Bogor to examine the feasibility of establishing a 30 000 hectare plantation of *S. stenoptera* forma Burck in the Sanggau district (Anon., 1986). The Department of Reforestation and Land Rehabilitation has also recently issued a small publication on the propagation, planting, and tending of illipe nuts (Anon., 1988).

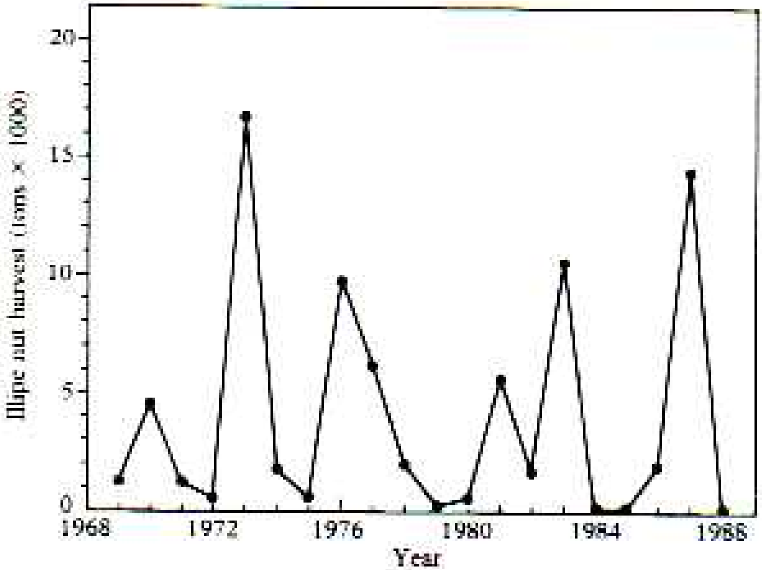
Constraints to Increased Utilization

In spite of the current interest in plantation development, increasing the export revenues obtained from illipe nuts is slightly more complex than simply increasing seed supply. The collection and marketing of illipe nuts in West Kalimantan is currently hindered by a variety of ecological, economic, and social factors, and it is important that these factors be considered before promoting any programme of increased utilization.

One of the major problems with illipe nuts is the sporadic nature of seed production. *Shorea* trees, like most other dipterocarps, produce fruit at irregular intervals of from 2 to 10 years (Ashton, Givnish, and Appanah, 1988). This reproductive behaviour, known as 'mast fruiting', is thought to be an evolutionary response to excessive seed predation.[2] What this means from a commercial standpoint, however, is that the availability of seeds from year to year is almost impossible to predict. As is illustrated by the production data shown in Figure 14.1, the total quantity of seeds collected from one year to the next may vary by more than three orders of magnitude. In 1987, for example, the total harvest of illipe nuts in West Kalimantan was in excess of 14,000 tons. The following year less than 50 tons were collected.[3] Clearly, it is extremely difficult to develop an export market for a plant resource with such unreliable supply characteristics. The discovery of annually fruiting varieties such as *S. stenoptera* forma Burck is a major step towards resolving this problem.

The illipe nut trade in West Kalimantan is definitely a buyer's market, and this market is currently dominated by the C.V. Mentawi processing plant in Pontianak.[4] Even under existing levels of exploitation, supply is frequently in excess of demand. At one point during the 1991 harvest season (January–March), for example, over 60 trucks carrying illipe nuts

FIGURE 14.1
Production of Illipe Nuts, West Kalimantan, 1968–1988



Source: Data from Dinas Kehutanan (1990).

were lined up outside the plant in Pontianak. Several of the drivers reported that they had been waiting to unload their cargo for over 10 days. After finally arriving at the gate, trucks containing seeds that had started to re-hydrate or germinate were simply turned away.

Local market conditions and prices for illipe nuts are also extremely elastic. Early in the season when supplies are low, collectors are usually paid about US$0.50 per kilogram for the dried seeds. As the season progresses and the capacity of the Pontianak plant approaches saturation, these prices may drop as low as US$0.20 per kilogram. Towards the end of the season, the plant may not even be willing to buy the product. The situation is even worse during a non-mast year when prices fall, rather than increase, in response to the reduced supply. The main reason for this is that the Pontianak plant also processes palm oil and cocoa butter, and a relatively large quantity of material is required to justify cleaning and readjusting its machinery to accept illipe nuts. As long as supplies fall short of this threshold value, there is a negligible commercial demand for the nuts. Given that reliable market information is rarely available to rural populations, the current illipe nut trade involves a considerable risk to both collectors and middlemen.

An additional limitation to the increased utilization of illipe nuts is the long travel time usually required to transport the seeds to market. Currently, the most extensive and productive collecting areas in West Kalimantan are located in the vicinity of Sintang and Putussibau at a distance of approximately 400 and 800 kilometres upriver from Pontianak. Seeds from these areas are transported to market in wooden houseboats and the trip takes several days. Regardless of the efficiency with which they were dried in the field, illipe nuts re-hydrate and are frequently attacked by fungus (*Aspergillus*, for example) if they are not processed within four to five days. A significant percentage of the illipe nut crop arrives at Pontianak in this condition and must be discarded. Although the establishment of collecting areas closer to Pontianak would help to reduce the frequency of seed spoilage, much of the forest habitat in this region has already been converted to rice fields and plantations of coconut, oil palm, and citrus fruit.

A final problem is that a large number of illipe nut trees have been felled. In addition to producing oil seeds, illipe nut trees are also the source of valuable red meranti and *balau* timber (Kartasujana and Martawijaya, 1973). Faced with falling prices and an uncertain market for the seeds, many local people have opted to sell their trees to loggers for an immediate, and frequently large, cash income. This practice appears to be especially common during non-mast years when there is little commercial demand for the seeds. A secondary effect of this logging activity is that local people have, in effect, relinquished their rights to a particular forest area by cutting their trees. According to traditional law, the occurrence of illipe nut trees in a forest grants usufruct or 'ownership' rights to the individuals or communities that planted or protected them. These rights are lost when the trees are cut, giving loggers easier access to the remaining merchantable timber within the forest. It should be noted that the felling and sale of illipe nut timber is officially prohibited by the Indonesian Department of Forestry.

Given these problems, there is an urgent need to develop new markets for the illipe nuts from West Kalimantan. The cosmetics industry is thought to be a particularly promising area in this regard as these products command a higher price on the international market than that of chocolate (Dixon, Roditi, and Silverman, 1991). The establishment of an information network to give price and market updates to local collector communities would also be useful. Existing radio programmes might be a suitable vehicle for this service. On the supply side, there appears to be little justification for establishing large-scale plantations of illipe nut at the present time. This activity would serve only to saturate existing markets even further and cause additional reductions in the price paid for dried seeds. Of perhaps greater importance, however, commercial cultivation would be extremely detrimental to those rural collectors whose livelihood depends on the periodic income generated by the sale of illipe nuts. A more useful strategy would be: (a) to improve the management of existing illipe nut stands; (b) to develop better techniques for drying the seeds in the field; (c) to look for additional varieties that fruit every year, and (d) to develop new production areas in the few remaining forests that are close to Pontianak.

Ecology of Illipe Nut Trees: A Case-study of *S. atrinervosa*

In early 1990, a long-term ecological study of illipe nut trees was initiated in the Sambas district of West Kalimantan. The study was designed to answer three basic questions about the abundance and productivity of these forest resources. First, what is the density of illipe nut trees in the residual forests which occur near Pontianak? Second, are local people familiar with any other species besides *S. stenoptera* forma Burck which exhibits an atypical or annual fruiting phenology? Third, how productive are 'natural' stands of illipe nut and what is their potential for sustainable exploitation and management?

After an extensive reconnaissance of the area, a suitable study site was selected along the slope of Gunung Poteng within the Raya-Pasi Nature Reserve. This reserve is located three hours north of Pontianak by road and contains approximately 3500 hectares of mixed dipterocarp hill forest (*sensu* Whitmore, 1984). The area was first designated a reserve by the Dutch in 1937 to ensure a continual supply of freshwater for the nearby town of Singkawang. The degree to which the forest at Raya-Pasi was used by local people prior to this time is unclear. The main reason for choosing this site was the reported existence of an indigenous illipe nut species that fruits every year.

A permanent study plot composed of 25 contiguous 20 by 20 metre quadrants was established on the north-facing slope of Gunung Poteng at an elevation of approximately 450 metres. Within each quadrant, all illipe nut trees taller than one metre were measured for height and diameter, and the exact position of each individual was mapped. After measurement, each individual was permanently labelled with a plastic or aluminium tag. Due to the abundance of illipe nut seedlings on the site, these individuals were sampled using randomly located one square metre plots (n = 200). Associated tree species larger than 5 centimetres in diameter (dbh) were also inventoried, measured, and mapped in each quadrant, and information on the local nomenclature and use of each taxa was recorded. A total of 1,891 individuals were tagged during this fieldwork.

Species Description

The illipe nut species of interest at Gunung Poteng is *tengkawang nyamuk*, or *Shorea atrinervosa* Sym., Subsection *Shorea*, Dipterocarpaceae. This species is a widely distributed forest tree throughout Sumatra and northern Borneo, including Sabah, Sarawak, and East and West Kalimantan (Symington, 1943; Browne, 1955; Wood and Meijer, 1964; Ashton, 1982). In West Kalimantan, *S. atrinervosa* occurs in primary forest at elevations of from 100 to 700 metres on a wide variety of substrates (Soewanda, Prawira, and Tantra, 1976). It is a common component of hill dipterocarp forests and may obtain high densities in selected habitats. The wood of *S. atrinervosa* is classified as a class I saw timber useful for planks, heavy construction, and structural material (Kartasujana and Martawijaya, 1973). The seeds are of intermediate size (2.5 by 1.5 centimetres) relative to other illipe nut species. Local people currently do not exploit the seeds of *S. atrinervosa* within the Raya-Pasi reserve, nor do they collect and sell any of the four to six species of illipe nut (like *S. macrophylla*, *S. pinanga*, *S. splendida*) that they have planted in their forest orchards. The low market price for the seeds, the restricted access to the reserve, and the fact that there is already a vigorous trade in other orchard products such as durian and rambutan appear to be primarily responsible for this pattern.

Density and Population Structure

The 1.0 hectare study site at Gunung Poteng contains a total of 868 trees—with diameters measuring 5.0 centimetres (dbh) and above—occupying a combined basal area of 55.8 square metres. Included among these trees are 25 species that produce edible fruits or nuts (like *Artocarpus*, *Baccaurea*, *Mangifera*, *Nephelium*), 35 timber species, 5 species producing *damar* (oleo-resin) or other useful exudates, 3 species whose leaves or bark are used medicinally, and 1 species whose fruits are used as a fish poison (*Derris*). The forest also contains 19 adult *S. atrinervosa* trees per hectare, which is an exceptionally high density for a species-rich dipterocarp forest (Whitmore, 1984).

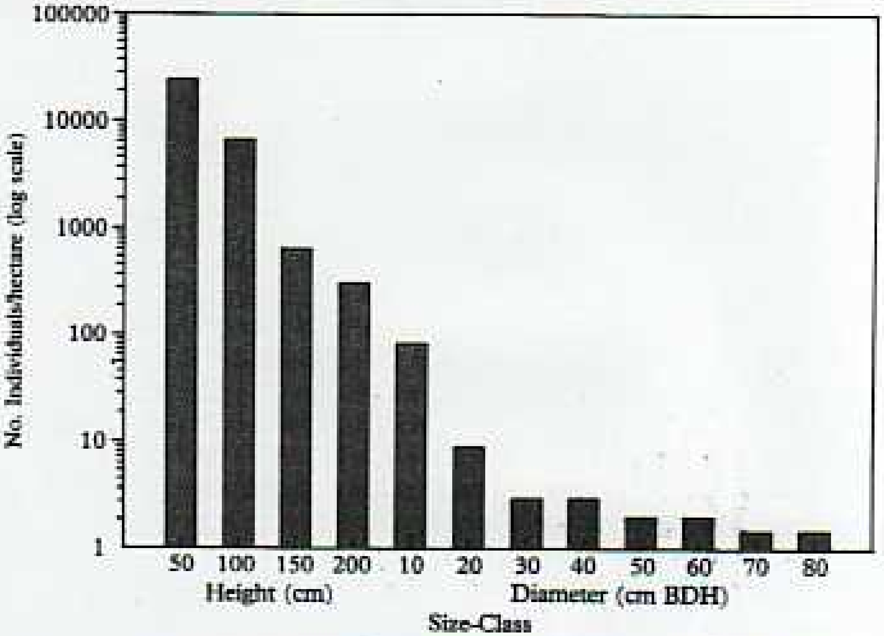
The size–class distribution of the *S. atrinervosa* population at Gunung Poteng is shown in Figure 14.2. The population has been divided into 50 centimetre height classes for seedlings and saplings and 10 centimetre diameter (dbh) classes for juvenile and adult trees. Two points in particular should be noted in this histogram. First, the population is characterized by a greater number of individuals in the smaller size–classes than in the larger ones and there are no obvious gaps or empty classes in the frequency distribution. This pattern strongly suggests that *S. atrinervosa* is continually regenerating itself in the forest.

The second point of interest in Figure 14.2 is the large abundance of seedlings (0–50 centimetres tall) and small saplings (50–100 centimetres tall). The population contains almost 50,000 seedlings and 7,000 saplings per hectare and, in some plots, seedling densities were in excess of 40 per square metre. In July 1990 when the original inventory of the site was conducted, most of the seedlings were 20–30 centimetres tall and still had their cotyledons or 'seed leaves' attached. These seedlings were clearly not slow-growing survivors from the 1987 illipe nut season. According to several local assistants, the *S. atrinervosa* trees at Gunung Poteng had produced fruit in early 1990. This finding was somewhat surprising, however, as 1990 was not a mast year for most of the other dipterocarp trees in West Kalimantan.

Fruit Production

In late October 1991, the *S. atrinervosa* trees on the study site began to flower again, and field studies were initiated to quantify the production

FIGURE 14.2
Size-Class Distribution of One Hectare Population of *Shorea atrinervosa* at Raya-Pasi Nature Reserve, West Kalimantan



Note: Log scale on y-axis and transition from height to diameter classes at 200 cm height class.

of illipe nuts by trees of differing size. To give a reliable estimate of fruit production, it is important that the crowns of sample trees do not overlap. To avoid this potential source of error, the vertical projection of the crown of all adult *S. atrinervosa* trees was first measured and then plotted on the stem map of the site. Based on these data, four completely isolated individuals were selected for measurement. Fifteen 1.0 square metre plots were randomly located under the crown of each sample tree, and the number of intact immature fruit, predated immature fruit, intact mature fruit, and predated mature fruit falling in these plots were counted and recorded at intervals of from 7 to 10 days.

The results from these studies are shown in Table 14.2. All trees drop a considerable number of immature fruits, and a large percentage of these are damaged by the larvae of an unidentified insect prior to falling from the tree. Total fruit production is directly related to both tree diameter and crown area and increases exponentially up to about 23,000 fruits for trees with a diameter of 62.4 centimetres. Predation of mature fruit once they are on the ground is relatively low; boring insects and occasionally squirrels and other rodents appear to be the primary sources of this mortality.

In an attempt to estimate the total production of illipe nuts by the *S. atrinervosa* population, regression analyses were used to derive a predictive equation relating tree size to fruit production. The total quantity

TABLE 14.2
Production of Immature Fruit, Mature Fruit, Per Cent Predation and Fruit Set for Four Adult *Shorea atrinervosa* Trees Growing on the Gunung Palung Study Site

	Tree Number			
	1–20	*10–13*	*16–61*	*24–74*
Diameter (cm dbh)	19.5	38.5	46.1	62.4
Sample area (m^2)	49.5	469.7	313.3	530.1
Immature fruit	62.4 ± 19.7	1,856.9 ± 459.6	6,017.5 ± 1,249.8	2,931.1 ± 558.8
Immature fruit predated	55.8 ± 17.3	1,626.9 ± 420.8	5,489.0 ± 1,216.4	2,507.0 ± 493.0
Per cent predated	89.4	87.6	91.2	85.5
Mature fruit	425.3 ± 84.5	10,087.0 ± 1,442.4	4,721.1 ± 1,062.8	22,650.8 ± 2,518.2
Mature fruit predated	62.3 ± 16.8	1,816.2 ± 339.6	880.2 ± 274.3	1,798.8 ± 421.4
Per cent predated	14.6	18.0	18.6	7.3
Per cent fruit set	87.2	84.4	43.9	88.5
Total Viable Seed	362.9 ± 67.7	8,270.8 ± 1,102.8	3,840.9 ± 788.6	20,852.0 ± 2,096.7

Note: Means ± standard errors are shown; all data based on the results from fifteen 1.0 m^2 sample plots positioned randomly under the crown of each tree. Fruit set represents the percentage of the total number of pollinated flowers which formed mature, ripe fruit.

of fruit produced by every adult tree was then calculated using this equation[5] and the data summed over all trees. The results from this procedure revealed that over 160,000 fruits per hectare were produced in 1991 by the *S. atrinervosa* trees growing on Gunung Poteng. Given an average seed weight of 6.4 ± 0.6 gram (n = 50), this production figure is equivalent to almost 1.1 metric tons of fresh illipe nuts per hectare.

It should be noted that this estimate is subject to several sources of error. Four trees is a very small sample size to measure the reproductive output of tropical trees, and fruit production by *S. atrinervosa* undoubtedly varies from one year to the next. In response to these factors, fruit production studies will be continued for at least one more year and, if possible, a larger number of sample trees will be monitored. Additional studies of seedling survival and the growth and mortality of adult trees are also underway. The results from the present work, however, do provide some interesting baseline data about the ecology and management potential of *S. atrinervosa*. The species exhibits an abundance of natural regeneration and appears to be expanding its population at Gunung Poteng. It is extremely high-yielding, and produces considerably more fruit than many cultivated species of illipe nut (Anderson, 1975; Chin, 1985). Finally, although it is premature to draw any definite conclusions about the reproductive phenology of the species after only two years, there is some evidence to suggest that local people are correct in assuming the *S. atrinervosa* is an annually fruiting illipe nut.

Illipe Nuts and the Management of Hill Dipterocarp Forests

Much of the remaining forest within a 200–300 kilometre radius from Pontianak is located on extremely steep slopes and rocky substrates.[6] In most cases, these forests have been spared because the habitat is too difficult to farm. A few small areas of hill dipterocarp forest are protected as part of community forest reserves or *tanah adat*. The great majority of these habitats, however, are classified as production forests and are exploited to varying degrees for timber. As is currently practised, selective logging on steep slopes is extremely damaging to forest structure, causes an excessive amount of soil erosion and downstream siltation, and may result in the loss of innumerable plant and animal species (Burgess, 1971; Nicholson, 1979). The results from the present study suggest that the uncontrolled logging of hill dipterocarp forests in West Kalimantan can also destroy a major supply of marketable illipe nuts, and with it a potentially important source of income for rural populations.

Promoting the establishment of illipe nut plantations and ignoring its natural abundance and productivity on local hill forests is a surprisingly inefficient and costly strategy for developing this resource. Selected tracts of forest specifically reserved for the collection of illipe nuts—and perhaps other non-timber resources—would undoubtedly provide sufficient material to meet the current market demand for the seeds. If market prices during a given year were prohibitively low, the seeds could simply be left the forest to regenerate. Management activities and enrichment planting could be initiated by local collectors concurrent with the first harvests to ensure that seed supplies keep pace with any future increases in demand. The competitiveness of *S. stenoptera* within the hill forest environment, as well as its potentially annual fruiting habitat, make this species particularly well-suited for planting.

The selection of these management areas should be prioritized based on the existing abundance of illipe nut populations, the proximity to Pontianak, the organization and willingness of local collectors, and the ecological importance of the habitat. Hill dipterocarp forests that play an especially important role in protecting the watershed of a particular community, for example, should be given high priority as restricted collection areas. In view of the small number of trees per hectare extracted in most logging operations, establishing these areas within existing forest concessions would result in only a negligible reduction in timber revenue.

The collection and sale of illipe nuts will never be competitive with timber extraction in terms of total revenues generated. But with careful site selection, secured access rights, and conscientious management planning, the development of the illipe nut trade could play a major role in promoting the conservation and sustainable use of West Kalimantan's forests.

UPDATE

Once a relatively obscure vegetable oil used as a cocoa butter extender (CBE), illipe nut butter is now a mainstream commodity. Export earnings from the dried nuts still represent millions of US dollars (Biro Pusat Statistik, 2000a). Unfortunately, the rate of forest loss in Indonesia has increased dramatically over the last ten years, and currently an estimated 2 million hectares of mixed dipterocarp forest, that is, illipe nut habitat, are destroyed or degraded each year (Holmes, 2000). In Kalimantan alone, the total area in forest declined from 40 million to 31 million hectares during 1985–97 (FWI/GFW, 2002). Land clearing for oil palms and the establishment of timber plantations appear to be the major sources of deforestation in West Kalimantan. Given that over million hectares have already been allocated for timber plantations in this province, and that only 120 000 hectares have been planted as of 2001 (Ministry of Forestry, 2001), the rate of forest clearing will undoubtedly continue unabated. Even assuming a minimum density of illipe nut trees in these forests, West Kalimantan is losing hundreds of thousands of potential oil-seed producers every year.

While some illipe nut trees are lost as 'collateral damage' when forests are cleared for alternative land-uses, others may be intentionally felled for their timber. Many of the same *Shorea* species that produce illipe nuts also produce valuable red *meranti* timber (PROSEA, 1994). There are currently 41 concessions over 3 million hectares in West Kalimantan (Biro Pusat Statistik, 2000b) that produce from 2 to 4 million cubic metres of logs each year (Departemen Kehutanan, 1986–99). It is not surprising that the short-term gain of felling a single illipe nut tree worth thousands of US dollars frequently takes precedence over collecting its seeds—which are worth about US$0.50/kg.

Recent research suggests that the regeneration of residual dipterocarp trees left in the forest after logging may be adversely affected by the disturbance. According to Curran et al. (1999), the characteristic mast-fruiting exhibited by dipterocarp trees is closely linked to El Nino Southern Oscillations (ENSO),[2] and these events are critical to regional seed production and seedling establishment. Logging alters these relationships by reducing the local density of adult trees, the spatial extent of the mast-fruiting event, and the response of the species to the ENSO event. Interestingly, the seeds produced by dipterocarp trees in logged forests exhibit lower viability and higher mortality due to predation. Of the 50 dipterocarp species included in the study, 48 species had not produced adequate seedling regeneration after three mast-fruiting episodes. In terms of the illipe nuts in West Kalimantan, this pattern probably translates to a significant decrease in the total amount of seeds available for harvest as well as the gradual elimination of many wild, low-density populations of *Shorea* trees.

Given these current trends, the high density, productivity, and fruiting phenology of *Shorea atrinervosa* make it more valuable than ever as a focal species for sustainable forest management. Recent administrative changes in the Sambas district of West Kalimantan, however, could severely threaten the original study population—and the seed source—for this species. At the time of the original study, the Raya–Pasi Nature Reserve was located in the Tujuh-Belas subdistrict of the Sambas district. As part of Indonesia's recent decentralization effort, the Sambas district was divided into two districts in 2000—Sambas and Benkayang (Kimura, 2002). The following year, the town of Singkawang was officially designated as a *kota*, or city.[8] Because of its proximity, the Raya–Pasi Nature Reserve was taken out of Tujuh-Belas and placed under the jurisdiction of the city of Singkawang. Singkawang's new designation will engender a lot of growth, development, and urban sprawl. How close is the forest to the city? The bustling market complexes of Singkawang are clearly visible from the slopes of Gunung Poteng.

1. The triglyceride fractions in illipe nut oil occur in similar proportions to those found in cocoa butter, and the oil can be blended with chocolate without altering the texture, gloss, or taste of the original confection (Godin and Spensley, 1971). The higher melting point of illipe nut oil makes it especially useful as a chocolate 'hardener'.

2. Mast-fruiting is thought to limit the abundance of frugivores and seed predators in the forest by concentrating their food supply into one brief period every few years when they are swamped by more food than they can possibly eat.

3. There are notable discrepancies in the official production and export data reported for West Kalimantan. In some cases, the export figures for illipe nut cited by the Biro Pusat Statistik are actually larger than the total production reported for that year by Dinas Kehutanan.

4. Other authorized illipe nut buyers of note in West Kalimantan include P. T. Sumber Alam, P. T. Sumber Daya, and P. T. Tangosa. During recent years, the Indonesian government has supported the C. V. Mentawi processing plant at Pontianak by levying a 20 per cent export tax on nuts while exempting the export of illipe nut oil (Altemeier, 1991). While this tax is no longer in effect, a substantial percentage of the illipe nut harvest in West Kalimantan is still exported in the form of oil.

5. The equation used in these calculations follows a general exponential model, that is, fruit production = a[illegible], and exhibits a coefficient of determination (r^2) of 0.83. Parameter values are $a = 7.08$ and $b = 0.04$.

6. There is considerable extension of logged-over peat swamp forest in the flood plain of the Kapuas River outside of Pontianak. Illipe nut trees, however, are rarely encountered in this habitat.

7. El Nino Southern Oscillations are periodic climatic phenomena caused by the interaction between the atmosphere and the surface water temperature in the eastern Pacific Ocean off the Coast of South America. ENSO events occur about every 2–7 years and often bring extended periods of drought to Indonesia.

8. Prior to this time, the only official city in West Kalimantan was Pontianak.

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