Picture 1: General Scheme of the establishment of "a rubber jungle"

a) On the left of the scheme, the vegetation is cut down and burned, then the field is cultivated (mainly rice and rubber)
b) Rubber trees receive the benefit of husbandry of the non-irrigated field until rice harvest time.
c) Rubber trees grow along with bushes
d) After 8 to 10 years the rubber trees are ready for tapping; the land is cleared and useful species are preserved
e) Natural plants regenerate during the lifetime of the agroforest (35 - 40 years), with the development of the physiognomy and function of the rubber jungle.

Note: the same process with several years delay is on the right of the scheme Arrangement of the small plots can form a large rubber jungle

In the rubber jungle

In lowland areas (≤ 200 m a. p. l.) in Sumatera, "a rubber jungle" can now be considered as the largest and richest reserve of forest plant and animal genetic resources.

together with food plants and forest regrowth. (*Picture 1*). After an average of 10 years, the farmers can tap their rubber trees for over 30 years.

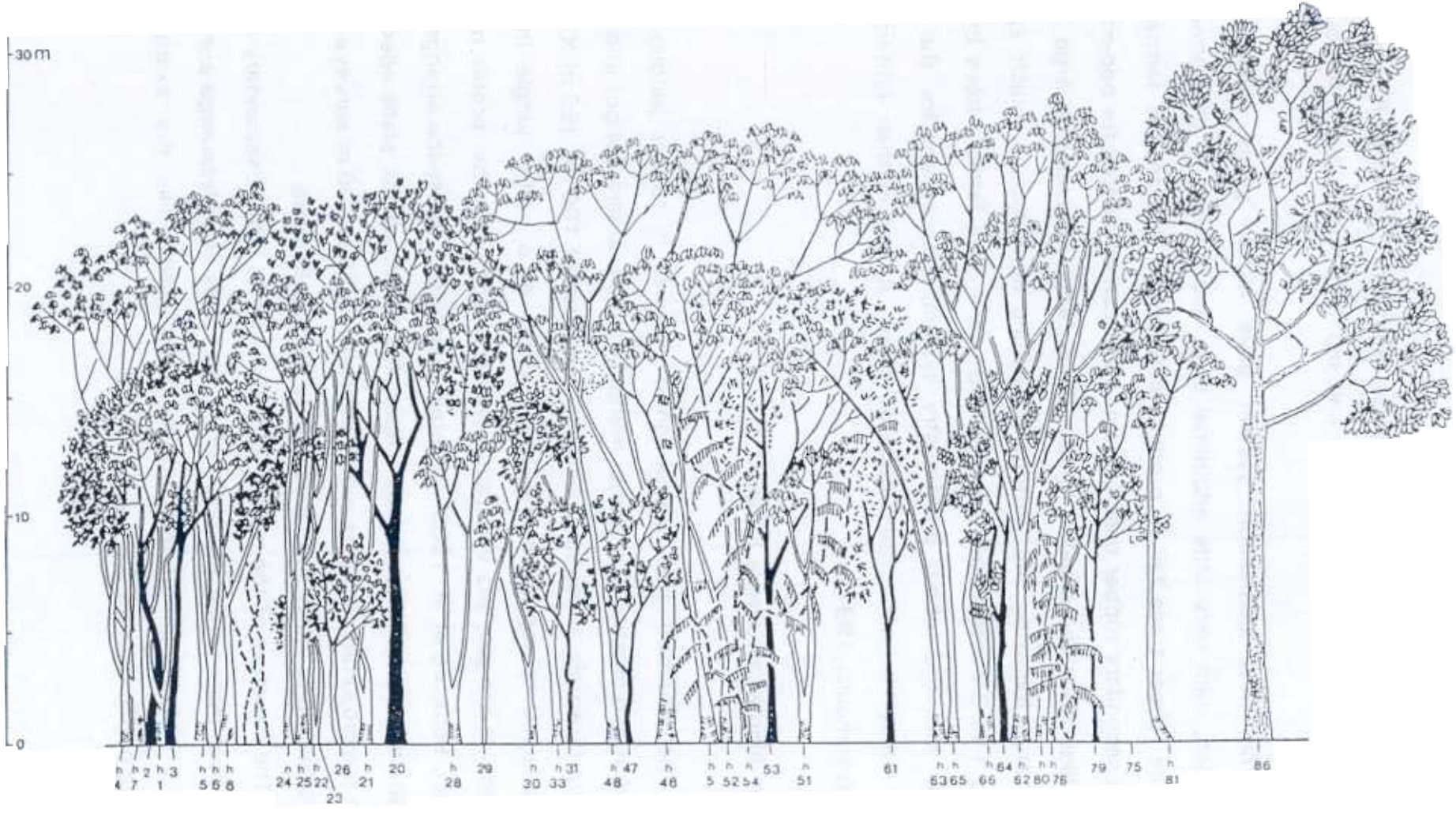
This new cultivation system gave higher yields than shifting cultivation, with very little additional cost, and no risk to the farmers: in case the rubber trees fail to produce satisfactory income, the farmers still have a secondary rubber based forest which can be cleared for non-irrigated fields like other uncultivated lands. Thus farmers develop a large rubber jungle area following the pattern of shifting agriculture, which spreads around 1 to 3 hectares after the second year. The farmers have been so familiar with the rubber agroforestry system, that except for the minor ethnic tribes like Kubu, they have all grown rubber in their non-irrigated fields (Laumonier,1991).

Rubber Jungle - or Jungle Rubber?

The structure and distribution of species in rubber jungles were studied in two locations, in Jambi (Rantau Pandan, Muara Bungo) and South Sumatra (Sukaraja, Musi Banyuasin). A land area of 100 m^2 (50 m X 20 m) was selected to represent the physiognomy of a rubber jungle in each location. In the plot the vegetation was analyzed using the profile method (Michon, Bompard et al. 1983) to obtain a picture of the space arrangement, the structure and floristic data. Apart from that, all the plant species of which the projected canopies would intersect with the 100 m surveyed lane, were collected to study their biodiversity (Rantau Pandan).

The structure of the rubber jungle is close to that of secondary forest, with rubber trees taking the place of pioneer trees like *Macaranga spp.* The structure can be categorized in two main grades like the example in Sukaraja profile (Picture 2):

Figure 2 : ARCHITECTURAL PROFILE OF A JUNGLE RUBBER



- with dense canopy trees of 20 - 25 m high, dominated by rubber trees (490 trees/ha), 260 non-rubber trees/ha consisting of 10 species with a diameter more than 10 cm, and 50 rattan bushes/ha

- with dense lower plants of 0.5 to 10 m high, dominated by lots of bush and small tree species , including seedlings and shoots of the canopy species

The biodiversity study in Rantau Pandan shows that there are 268 species of plants besides rubber, all of them originally came from a natural forest, classified into 91 wood trees, 27 bushes, 97 vines, 23 herb, 28 epiphyte species and 2 parasites. The biodiversity of the studied area is comparable to that of secondary old forests. Compared to commercial plantations which include very few species other than rubber, the importance of a rubber jungle for the sustainability of the biodiversity of forest plants must be underlined.

As a whole a "rubber jungle" pictures a secondary rubber based forest which may last for 40 years or more before it is replanted, while the regrowth of a secondary forest in the shifting agriculture rarely reaches 20 years. The considerable length of time gives more opportunities to non-pioneer primary forest species to develop An abandoned rubber jungle will develop into a mature forest with fewer and fewer rubber trees per hectare.

The Extensive Economic Functions

The information below has been collected through a socio-economic survey in South Sumatra, involving more than 350 farmers in 31 villages,

[i] Table 1: Jenis tumbuh-tumbuhan yang terutama di dalam "hutan karet" (Sumatra bagian selatan)

Variaty	Family	use	area	local name
Mangifera spp.	Anacardiaceae	fruit, timber	M.B/S.	Mangga hutan
Alstonia Angustiloba	Apocynaceae	timber, resin	M.B/S.	
Durio zibethinus	Bombacaceae	fruit, timber	M.B/S.	
Flacourtia rukam	Flacourtiaceae	fruit, timber	M.B/S.	
Garcinia spp.	Guttiferae	medicinal, timber	M.B/S.	
Lauraceae spp.	Lauraceae	timber	M.B/S.	
Archidendron pauciflorum	Mimosaceae	vegetable, timber	M.B/S.	Jiring
Parkia speciosa	Mimosaceae	vegetable, timber	M.B/S.	
Artocarpus integer	Moraceae	fruit, timber	M.B/S.	
Artocarpus elasticus	Moraceae	fibre material, timber	M.B/S.	
Eugenia spp.	Nyrtaceae	timber	M.B/S.	
Calamus spp,	Palmae	handicraft	M.B/S.	
Arenga pinnata	Palmae	fruit, sugar	M.B/S.	
Areca catechu	Palmae	pasionate, medicine	M.B/S.	
Milletia atropurpurea	Papilionaceae	timber	M.B/S.	Mibung, meribungan
Vitex cf. pubescens	Verbenaceae	timber, medicine	M.B/S.	Leban
Peronema canescens	Verbenaceae	timber, fench	M.B/S.	Sungkai
Dyere costulata	Apocynaceae	resin, timber	M.B.	
Baccaurea cf reticulata	Euphorbiaceae	timber, estates material	M.B.	Lei
Pangium edule	Flacourtiaceae	medicine, timber	M.B.	
Sonerilla sp.	Melastomaceae	garden species	M.B.	
Bulbophyllum lepidum	Orchidaceae	garden species	M.B.	
Salacca spp.	Palmae	fruit	M.B.	
Coffea canephora	Rubiaceae	pasionate, fire wood	M.B.	
Dimocarpus longan	Sapindaceae	fruit, timber	M.B.	
Styrax benzoi	Styracaceae	resin, timber	M.B.	Komenyan, Kemenyan
Dillenia obovata	Dilleniaceae	timber	S.	Simpuh
Lithocarpus cf. elegans	Fagaceae	timber	S.	
Bellucia sp.	Melastomaceae	fruit	S.	
Helicia robusta	Proteaceae	timber, vegetable	S.	
Nephelium lappaceum	Sapindaceae	fruit	S.	
Schima eallichii	Theaceae	timber, fish poison	S.	

Daerah: M.B. = Muara Bungo, Jambi / S. = Sembawa, Sumatra Selatan

[i] tbl1.ras

and an agronomic survey of more than 280 rubber gardens. (Gouyon and Nancy 1989; Gouyon, Nancy et al. 1990). Additional data on household expenses have been recorded based on an interview with 20 farmers in 2 villages, the financial flow of the families have been monitored weekly for a year using 9 respondents in 2 villages. The data of the jungle rubber in Jambi have been obtained by interviewing respondents in 90 villages (Gouyon, Nancy et al. 1991).

Most of the literature on smallholder rubber outside Government projects in Southeast Sumatra (Thomas 1957; Barlow and Muharminto 1982; Cottrell 1990) has been focused on rubber trees and their secondary plants during the early phases. The perennial non-rubber plants have been overlooked because the yield has been non-commercial, and because most of the agronomists and economists do not have the necessary background to identify forest species with economical values.

Thus botanical contributions (de Foresta 1992) have been important to identify the components.

Source of income: rubber and others

If we observe a "rubber jungle" for its economic value, we will notice that rubber yields up to 85% of the average income per ha per annum. A rubber tree is tapped from 3 to 5 days a week. The product is sold to a local broker weekly and provides some cash throughout the year.

Food crops and commercial crops growing along with young rubber trees (for instance rice, bananas, pineapples, vegetables, etc.) may become an important source of income from one until three years. Afterwards, erosion, weeds and the shade of the rubber trees will prevent further cultivation. Although only temporarily, the crops have an important role as

[1] Yet the quantitative data concerning the contribution of non-rubber perennial plants presented here must be considered as a rough estimate.

the source of income for the farmers during the first years The crops function as cover crops to prevent weed growth and produce a fast income to pay for weed control, which needs to be done to protect young rubber plants. The crops yield various products either for self-consumption or for commercial purposes when rubber price drops. (Thomas 1965) "Producing their own rice" for the farmers also means earning respect from other people in their village.

The non-rubber components in a rubber jungle provide various products with economical values (de Foresta and Michon 1993). Various kinds of fruit trees grow spontaneously because their seeds have been distributed by some kinds of animals, and because there are many varieties of plants in the rubber jungle. (*Table 1).* The fruit helps to balance the farmer's family diet, especially their children's, and increases the nutrition values. Species for furniture wood are well taken care of - especially in areas where wood from natural forests have become very rare, like in South Sumatra. The farmers also obtain their firewood from the jungle for household consumption. And when the land is going to be replanted, the rubber jungle will provide all the wood needed for fencing, thus the farmers do not need to purchase iron wires for the purpose. Wood and firewood have become very important to the farmers, because logging activities have caused the farmers to lose other kinds of resources. Farmers also mention the use of some species for traditional medication. More inventory needs to be carried out to evaluate the potentials of the medical plants for use in a large scale

Contribution to the family's property.

Just like in other perennial tree cultivation systems, a rubber jungle will prosper the farmers by providing them with a property and an income. The traditional land principles consider a family land as a personal property

as long as the land is exploited. Thus the rubber jungle can become a personal property which can be sold or passed on to the children or mortgaged. The existence of rubber trees which are potentially productive adds to the value of the land.

Owning a rubber jungle means that the farmer can sell the property for the purpose of supplying the need for a big amount of money , for instance for wedding celebrations, and for a credit guarantee in inland markets. But most of the farmers have been unable to obtain a certificate for their lands, because of the complicated procedure and high cost of acquiring one. This will lead to fights among the villagers or with outside parties for the property, and limit the use of lands for a bank loan security.

Minimal input by using bushes to control weeds and mammals

Agronomists often consider the rubber jungles as poorly maintained, because they are covered with dense bushes, which impede the rubber growth (ready for tapping after 8 to 12 years) compared to weed free plantations (ready for tapping after 5 to 7 years).

But the farmers consider the bush species as cover plants to control highly competitive weeds like *alang-alang*, which otherwise requires the use of expensive herbicides The farmers show that compared to the bush cover, *alang-alang* will postpone tapping readiness to 2 or 3 more years, and will also cause the probable destruction of one third of the rubber trees by fire, during their early years. Moreover, according to the farmers the bushes protect the rubber plants from tapir, deer or boars, which will feed the barks of young rubber plants or rubber shoots.[2] The wood fence constructed by the farmers can only last for two or three years Without the protection of the bushes afterwards, the farmers have to maintain the

[2] It is unclear how the bushes protect the rubber plants from mammals. Maybe they function as impediments or deviation of the mammals' attention to young rubber plants.

fence along with the rubber growth at high cost. A rough estimate shows the bush cover has saved the farmers Rp. 500 000 for material herbicides and workers for rubber plant protection before the tapping phase a considerable amount compared to the income of the farmers

Economic life value with spontaneous regeneration.

Rubber trees in well managed plantations can hardly be tapped for more than 28 years because of the decay of the barks. Likewise the trees in a jungle rubber are often poorly tapped, because of the use of unskilled tappers that belong to the family, for instance children. The speed of tapping has also been more important than the quality, to save energy. Therefore each tree can hardly be tapped after 20 years. Surprisingly a rubber jungle can be exploited for more than 30 years: if the first planted decays, often the farmers replace it with a shoot which grows spontaneously in between the trees. Yet, because rubber growth is not optimal under shades, this regeneration can not prevent the decrease of the tree population from 500 trees/ha to 200 trees/ha after 40 years. Thus the method is not profitable anymore, and the farmers have to do a complete replanting if they still need to cultivate the land

A rubber jungle ... what is its contribution to biodiversity?

As a land use system where tree crops are deliberately planted in the same land management unit with agricultural plants and /or livestock in a space arrangement or temporary arrangement, with ecological and economical interactions between various components (Lundgren and Raintree 1982, in (Nair 1989)), a rubber jungle definitely belongs to an agroforestry system.

Besides, as an agricultural system which sustains forest ecosystem characteristics, with large ecological and economical diversity, a rubber jungle belongs to "the complex agroforestry system or agroforest" - like the smallholder resin garden in Lampung (Torquebiau 1984; Michon 1985; Mary and Michon 1987, Michon 1991) or the durian based mixed gardens in West Sumatra (Michon, Mary et al. 1986). This type of agroforestry is very common in areas where the population is relatively low (fewer than 200 persons/km^2) in Indonesia, and where the natural forest is near in terms of distance and time (de Foresta and Michon 1993).

Preserving biological diversity may actually be important for human beings as a whole - natural forest and agroforests are considered as a natural reserve for species that will prove to be useful in the future. long term goals often clash with pressing income needs in line with increase of population in developing regions

The complex agroforestry system may become an example of an agricultural system where biodiversity produces financial income quickly. In the case of "a rubber jungle", the biodiversity of plants has been performing two economical functions;

increasing the farmers' income with cash or food for their own consumption, so that they can reduce their dependence on rubber;

- enabling the farmers to enlarge the cultivated lands with minimum capital and work power input.

Yet can the low-input/low-yield system be maintained, considering the changing economic conditions, especially the threat of increasing population?

Note: This contribution is a summary of three published articles:

1/ de Foresta, H. and G. Michon (1991). Agroforesteries Indonésiennes: systèmes et approches. Communication à l'Atelier "Quelles agroforesteries pour l'Orstom?', Paris, Octobre 1991.

2/ Michon G. et Bompard, J.M. (1987): "Agroforesteries Indonnésiennes: Contributions paysannes à la conservation des forêts naturelles et de leurs ressources. " Revue d'Ecologie (La Terre et la Vie) 42: 3 - 37

3/ Gouyon, A., H. de Foresta and P. Levang 1993). "Does 'jungle rubber' deserve its name? An analysis of rubber agroforestry systems in Southeast Sumatra." Agroforestry Systems 22:182 - 206.

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[1] ORSTOM-ICRAF S.E. Asia, Bogor, Indonesia

[2] CIRAD-CP, Paris, France
[1] ORSTOM-ICRAF S.E. Asia, Bogor, Indonesia

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MAP OF INDONESIA

4. Indonesian smallholder rubber in the agroforestry system

4.1 *The importance of the smallholder sector*

The smallholder sector accounts for 84% of the country's rubber area and 73% of the total rubber production. In that respect, the situation in Indonesia is intermediate between Thailand (95% smallholders, 5% estates) and Malaysia (60% smallholders, 40% estates). There are approximately 1,3 million farmers' households relying on rubber production producing 925 million tons on 2,658 million of hectares, compared to around 650 000 ha for the estate sector. Various government programmes since the 70's have reached only about 15% of the farmers (see § 6). So far, the hectarage included in these programmes is only 362 000 ha out 2,65 million ha in the smallholder sector

4.2 "Jungle rubber', a rubber - based agroforestry system

"Jungle rubber" systems are now well known (A Gouyon, C Nancy, C Barlow) Jungle rubber can be established at very low cost Maintenance of rubber in the first year is limited to that required by upland rice. Then farmers usually let rubber compete with secondary forest regrowth. First tapping occurs 8 to 10 years later Jungle rubber is composed of rubber and other trees, many of them with multiple purposes: for example, fruit or nut production timber, rattan. The system provides diverse sources of income

The secondary forest associated with rubber maintains biodiversity and a forest-like environment. It also contributes to soil conservation and water management. Furthermore, jungle rubber systems are fire resistant. Overall, jungle rubber is a sustainable land use system that fits farmers' household labour supply and financial constraints

Low productivity: the key shortcoming of "jungle rubber" systems

Jungle rubber systems are characterized by very low productivity due to poor planting material (unselected seedlings). Farmers' average yield[1] is low, 593 kg/ha compared to that of the private estates (1065 kg/ha) or the governmental estates (1311 kg/ha) (Statistik karet, DGE, 1992). There is not an adequate supply of higher yielding planting material (HYPM), in particular certified clones Even if there were such a supply, farmers may not have cash or credit to afford the cost of clones. Furthermore, much planting material is of uncertain quality. *Low cost techniques to raise productivity are an important requirement to fit the constraints of farmers.*

Lack of information on technical innovations is another major constraint. There is little extension outside rubber projects and almost none for farmers in pioneer zones. The efficiency of the

[1]Rubber yield is based on area with mature trees. The total rubber cropped area also includes immature trees. Yield and area statistics at the national level are subject to uncertainty.

extension services is limited by the lack of appropriate technologies for the farmer

Poor soils and other agronomic problems also contribute to low productivity. Sometimes the water table is only 50 cm deep (in Kalimantan). Leaf diseases make strong attacks especially in West-Kalimantan Wind damage is a severe problem in North Sumatra These local factors mean that rubber varieties and techniques must be adapted to help farmers to cope with these local problems.

Despite low productivity, there are few alternatives for farmers that are as profitable as rubber in large areas of Sumatra and Kalimantan. Increasing the productivity of rubber including rubber agroforestry systems) is still the most important way to improve farmer's income.

4.3 Smallholder rubber planting is expanding

HYPM availability is still limited in most provinces, except South and North Sumatra. However, there is a high level of planting and replanting in many areas, including Jambi, Riau, West Sumatra, and Bengkulu in Sumatra as well as West, Central and South Kalimantan, and, more recently Ceram/Maluku and Irian Jaya at a very small scale Replanting also is significant (South-Sumatra is a good example) There is in fact a large pioneer zone in many provinces. This is happening for various reasons

1 - Planting rubber is a means of land acquisition in areas, where land is still plentiful. There is still considerable scope for further rubber expansion of production in Indonesia, in particular in Central Sumatra (Riau and Jambi), Central and South-Kalimantan, and Irian Jaya. These are locations suitable for rubber but not for most other crops, (especially foodcrops) due to poor soils Rubber agroforesty is a sustainable alternative to shifting cultivation of foodcrops in many areas

2 - Planting rubber helps established claims to land. *Land status is an important factor in the investment strategy of the farmer Planting rubber is part of the land acquisition process.*

3- Rubber still is seen as a profitable, long term income source, with flexibility in the management of production The possibility of stopping the tapping without damaging the trees gives the farmers flexibility and reduces risk. In that respect, rubber trees may be considered as a "bank" . *Risk management is also a major objective for these low-income farmers.*

4 - Rubber planting is one way to increase the value of degraded lands (Oil palm and coconut may be alternative crops depending on agro-ecological zones. Another alternative might be timber production).

5 - Rubber is a sustainable alternative to shifting cultivation of foodcrops in these areas and gives a reliable source of income to farmers. Sustainability of such systems is not only financially feasible, but also environmentally sound. The current system of jungle rubber maintains a high level of biodiversity (De Foresta,

1990). The forest-like ecosystem also protects soil and water resources. Soil fertility is conserved under rubber as latex tapping does not export significant nutrients. *The evolution of the current jungle rubber into RAS higher-yielding (rubber agroforestry systems) can raise productivity and help conserve Indonesia's natural resources, including soil, water, and the forest-like environments necessary to sustain biodiversity.*