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Can Gaharu Be Harvested Sustainably? A Case Study From East Kalimantan, Indonesia

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Introduction

Since the late 1980s, non-government organizations (NGOs), agricultural extension workers, and international development agencies have devoted increasingly more attention to the potential for managing and sustainably exploiting non-timber forest products (hereafter NTFPs). The underlying objective behind the efforts to promote NTFPs on the national and international levels was to create an alternative to the conventional exploitation of the forests (particularly in the tropics) — i.e., timber extraction and/or conversion (Prance et. al 1987; DeBeer & McDermott 1989; Panayotou & Ashton 1992; Plotkin & Famolare 1992). The gains (or positive impact) that could potentially arise from establishing the NTFPs as the main resources extracted from the forests are thought to be numerous. First, as imperative as ecological concerns are, the most important consideration relating to non-wood forest products seems to be their potential for providing greater financial benefits for local communities than extraction of timber or conversion to full-time sedentary agriculture (Gradwohl & Greenberg 1988; Fearnside 1989; Peters et. al 1989). The second key assumption is that, in principle, the exploitation of NTFPs will leave tree cover intact, thus providing a viable solution to the problem of deforestation. Cumulatively, it is hoped that extraction and marketing of non-woody species may provide a means to balance the concerns associated with both conservation and development in the rural areas (Schwartzman 1989; Allegretti 1990).

Economic and ecological studies carried out among the indigenous communities in South America (particularly in Amazonia) provided an early confirmation of the projections about the potentially high economic (marketing) value of fruit trees, saps, and latexes (Peters et. al 1989a; Peters et. al 1989b; Vasquez & Gentry 1989; Anderson & Jardim 1989). However, as the studies of the economic value of these resources became more numerous it became increasingly apparent that the estimates of the monetary incomes that indigenous collectors could obtain from NTFPs were grossly overestimated (Saw et. al 1991; Pinedo-Vasquez et. al 1992; Appasamy 1993; Chopra 1993; Godoy et. al 1993). In spite of this troubling revelation, it was assumed that the economic success (however erratic) of certain Amazonian communities specializing in NTFPs was, however, an indication of ecological sustainability (i.e., steady income = steady

supply of forest products = sustainable management of the species) (Fearnside 1989). Eventually, it became clear that economic/ecological compatibility was the exception rather than the rule and that rural communities exhibit a distinct tendency to over-exploit non-timber forest resources (Kahn 1988; Nepstad et al. 1992; Bodmer et. al 1993; Padoch 1989; Bowcer 1992, Peluso 1992a; Peluso 1992b).

It is important to point out that studies which have shown the ecological non-sustainability of the exploitation of forest products rarely mention the economic and political factors, such as influx of foreign capital and the importation of external labor force, as the primary causes of the negative ecological consequences. In this paper, I will attempt to illustrate the impact of these external interventions on the economic and ecological status of the *Aquilaria* spp. in the Berau River system, East Kalimantan, Indonesia. The case of *Aquilaria* is bound to be somewhat controversial since the resource extracted from the trees of this species, a diseased fragrant heartwood, technically does not qualify as a non-wood forest product. Furthermore, as I will show, the extraction techniques used to obtain the heartwood invariably result in the destruction of the tree containing the resource. From the outset then the exploitation of the gaharu wood seems to be anything but sustainable. However, by drawing a clear distinction between the methods used to search, sample, and extract gaharu by local communities (particularly formerly nomadic Punan) and by opportunistic collectors (usually migrants from other islands employed by the pharmaceutical companies) I will argue that extraction of gaharu could be carried out in a sustainable manner.

Following some introductory information on history and traditional trade in forest products (of which gaharu was an important part) during the pre-colonial as well as colonial period in Southeast Asia, I will discuss what is known about the ecology of *Aquilaria* trees. For reasons of its questionable status as a non-timber forest product as well as because of its general obscurity, gaharu has not as yet been studied in detail by the scholars interested in NTFPs. Consequently, such fundamental questions as: a) temporal and elevational distribution of *Aquilaria* (locally in Borneo); b) soil requirements; c) population size, density, distribution, etc. are very inadequately understood. Finally,

the crucial question of fungal infection which is the direct cause for the formation of gaharu in *Aquilaria* trees has not been explained and is a subject for speculation. Given the very limited data on the ecology of *Aquilaria*, this section will understandably be partly conjectural. In the third section, I will focus on the political economy of gaharu in the Berau region of East Kalimantan. In the contextual framework of economic exchanges between the interior and coastal areas, I will discuss differences in the methods for the extraction of gaharu by formerly nomadic Punan and by commercial collectors working for the companies which process it and ship it overseas. By juxtaposing different methods of extraction and ecological properties of the *Aquilaria* trees, I will attempt to show the existence of a possibility, at least in theoretical terms, for a non-destructive exploitation of gaharu.

1. Gaharu Wood — A Historical Background

“Gaharu wood (also known as aloes wood, agaru or aghila) is the aromatic, resin-impregnated, diseased heart wood from five species of tree in the genus *Aquilaria*” (Paoli et al. 1993:5). The geographical range of the tree species extends from northern India in a southeastern trajectory, to Indonesian islands (Hou 1960). Gaharu does not form in every *Aquilaria* tree. Its presence depends upon the fungal infection which causes the resinous substance to form on the tree (Battacharyya et. al 1952). In contrast to sap and latexes extracted from various tree species in the tropical forests, gaharu is not tapped because it does not secrete from the tree once the incision is made. The fungal pathogen responsible for the formation of gaharu infects and impregnates the wood tissue resulting in the resinous deposits in different parts of the tree (Gianno 1986). These deposits may occur in the form of veins of irregular thickness running throughout the length of the tree (from the roots to the canopy). However, it may also assume the appearance of bulges of different shapes and sizes. Gaharu wood is obtained by cutting the fragrant, infected portions from the host tree which invariably does not survive such a procedure.

Gaharu wood has always been an important natural product from the forests of insular Southeast Asia. Presently, Indonesia along with Vietnam, Cambodia, and Burma are the leading exporters of this fragrant wood. The primary importers are the countries with strong cultural traditions involving ceremonial burning of incense, such as: Saudi Arabia, Jordan, Japan, Taiwan, and Hong Kong (Nurhayati 1988). In addition to its cultural and ceremonial significance, the leading importers of gaharu use it extensively as a raw material for variety of oils, perfumes, and medical remedies. Because the market demand is high and supplies are declining, the value of gaharu is continuously increasing, thus escalating the frequency of extraction (Peluso 1983).

The present day strong demand for gaharu in the Middle and Far East is the result of the centuries (if not millennia) old tradition of economic exchange with tropical

South and Southeast Asia. It seems that the Indian sub-continent was the initial center where gaharu was collected for medical purposes as well as for trade (Bhishagraha 1907; Paoli 1993:6). The aromatic qualities of gaharu were also highly appreciated (Miller 1969).

With the expansion of cultural and economic contacts between Hindu kingdoms and the regions further east through maritime trade, came the discovery and the establishment of new suppliers of gaharu. During the first millennium A.D., the areas of contemporary Burma, Thailand, and Indonesia came to the forefront as the main exporters of this resource (Burkill 1935). Another factor contributing to the increasing consumption (and, as a result, exploitation) of gaharu wood was the intensification of trade between imperial China and its peripheral (mostly Southeast Asian) tributary states. By the year 300 A.D., gaharu was already well established and coveted import by the imperial court (Wang 1958). The later Chinese sources, dating back to the medieval era in Europe, indicate that the amounts of gaharu imported by the imperial China as well as the number of exporters of this resource were rising continuously (Wheatly 1959). It appears, therefore, that gaharu has historically been one of the most important trade items within a wide range of tropical Asiatic forest exotica. In the specific context of Borneo, gaharu, having outlasted rhinoceros horn as the leading trade item, has maintained its exclusive status as the most desirable product for export until the present day.

The rich historical tradition in local and regional marketing of gaharu has important implications for the purposes of this paper. The contemporary intensification of exploitation of this resource comes as no surprise since millennia-old traditions have made the trade routes as well as importer/exporter ties firmly established. In spite of being widely known and utilized in Asia and of great cultural and economic importance, the ecological and biological properties of gaharu remain virtually unknown to the western academia. It is to this poorly understood aspect to which I will now turn.

2. Ecological Characteristics of Gaharu (*Aquilaria*).

As I have already mentioned, the genus *Aquilaria* is comprised of five species of trees. In Borneo, only three of these species have been reported: *A. malaccensis*, *A. microcarpa* Baill, and *A. beccariana* van Tiegh (Hou 1960). It is unknown which of these species is the principle provider of the gaharu heart wood. What has been reasonably well established, however, is that *Aquilaria* trees are distributed throughout diverse forest types and that in neither of these zones *Aquilaria* is found in high densities (Beniwal 1989). The first long-term quantitative ecological study of the *Aquilaria* stands, carried out by Paoli et. al (1993), confirms earlier studies. Concentrating their efforts on Gunung Palung National Park in West Borneo, the researchers found that *Aquilaria* densi

ties were extremely low in all five forest formations where its presence has been detected: freshwater swamp, alluvial bench, lowland sandstone, lowland granite, and lower montane (ibid.:17). The density ranged from 0.16 to 0.32 per hectare with similar distribution across various forest types. Other sources, e.g. (Sidiyasa et. al 1986), indicate far higher densities of *Aquilaria* in south Borneo. However, these concern the clumps of *Aquilaria* trees which were purposefully sought out. Consequently, these data are not representative of the average spatial distribution of this tree.

While it appears that *Aquilaria* trees (per ha) are a fairly rare sight in Borneo rain forests, the trees which have been infected and contain the resinous gaharu substance are even rarer. Gianni (1986), for instance, speculates that only 1 in 10 *Aquilaria* trees may actually have the highly coveted gaharu content. Other authors indicate that whether or not a tree contains gaharu may be strongly linked to such factors as soil type and elevation. Jessup (1983) points out that some gaharu collectors in East Kalimantan associated infertile soils with a greater likelihood of finding gaharu in *Aquilaria* trees growing in such locations. There are also reports positing that fungal infection, which the formation of gaharu is dependent upon, may occur only within certain elevation zones (Dixon et. al 1991).

Probably the most significant and least understood factor responsible for the development of gaharu in *Aquilaria* trees has been the aforementioned fungal infection. There is no common understanding as to the particular sequence of events which lead to the establishment of the infection. Some researchers attempted to solve this conundrum by transplanting parts of the diseased tree onto a healthy one in order to observe the progress of infection (Beniwal 1989). Such experiments, however, did not produce the same infection patterns as was observed on naturally infected trees — i.e., infection was confined to the area where the infected piece was transplanted. The limited success of such experiments (partly aimed at exploring the potential for *Aquilaria* plantations), is an indication of the confusion concerning the mechanism of the infection itself. Some assume that the pathogen is located in the soil and, as a result, it infects the trees through the roots. Other researchers, e.g. Corner (1952), speculate that the disease may be air-borne entering the trees through cuts and openings in the bark. Still other reports (Jessup 1983) suggest that insects may be carrying the disease as gaharu deposits are frequently associated with small colonies of ants. It is not unthinkable that the infection may not actually follow a singular path but that all three venues may cumulatively play a role in creating the situation conducive to the successful establishment of the pathogen.

The uncertainty and unpredictability of the process of infection makes it highly unlikely that in the immediate future the collectors of gaharu from the naturally growing trees will face competition from plantations.

3. Political Economy of Gaharu — the Case from Berau Region, East Kalimantan.

3.1 Trading Networks — a Historical View.

Berau is one of five administrative units called *kabupaten* (regency) which together comprise the Indonesian province of East Kalimantan (East Borneo). The main topographic feature in the regency is the Kelai-Segah river system which drains the entire area, constitutes the major artery for regional transportation, and also serves as the main point of reference for the topographic classification of the surrounding country. As a result, the regency is divided (from the coast into the interior) into: coastal plains, mid-river lowlands, and mountainous upper river regions. Until recently, i.e. the 1970s, the entire land surface in the regency has been classified as primary forest (*hutan rimba*) (Humas 1992). With the introduction of mechanized logging in the late 1970's and with the presently contemplated plans to open one of the largest paper mills in Borneo, the forest cover in Berau is under tremendous pressure and it is shrinking rapidly.

Virtually all horticultural groups present in Berau (e.g., Segai, Kenyah, Modang) have been participating in the collecting of forest products as a part time activity. Traditionally, however, it was the prerogative of the nomads (Punan & Basap) to search for various forest products on a full time basis. During the pre-colonial as well as during the colonial period, the nomads in Berau were the primary sources of such valuable items as: rhino horn, edible bird's nests, gold, and gaharu wood. The Dutch colonial administration, determined to keep interventions into the internal affairs of the region to the minimum (so as to reduce the administrative expenditures), allowed the social and political structures in Berau to continue unchanged, so long as the external contacts and defense affairs were under control. As a result, the traditional exchange networks and long established trade arrangements of patron-client type continued well into this century.

Until the 1940's, Berau was divided into two sultanates (Sambaliung & Gunung Tabur) which controlled Kelai and Segah rivers respectively. Theoretically, sultans (or *rajas*) had the exclusive control of the most valuable sites (gold panning locations, birdnest caves, etc.) and they were also entitled to 10% tax on all forest produce transported downstream (Achmed 1979; Walchren 1907). The fact that they often were not able to enforce this rule does not diminish the fact that sultans (& their entourage) were on the top of trading hierarchy. The second level was comprised of merchants plying the rivers between the Dayak villages in the middle part of the country and the coastal centers. The fourth party involved were the horticultural Dayak peoples who were within close proximity to their nomadic neighbors. The Dayak thus acted as the primary middlemen between nomadic collectors of forest produce and river merchants (Rousseau 1990).

This trading network has undergone dramatic

changes in the period following the independence of Indonesia in 1949. The sultanates in Berau have been abolished. The control which Dayak peoples had over the nomadic Punan & Basap (partly through the threats of warfare and head-hunting raids) has been eliminated. The end result is that the traditional differentiation of economic activities (specializations) among the indigenous communities has been significantly reduced. Presently, both former nomads as well as horticulturists are considered equally desirable primary sources of the forest produce. With the dissolution of the Dayak military and political power, the river merchants are now in position to by-pass the Dayak middlemen and seek direct contacts with the nomads for the purposes of trade.

3.2 Indigenous Methods of Extracting Gaharu — an Example from the Punan of Long Suluy on the Upper Kelai River.

During the summer of 1995 I had an opportunity to visit the Punan village of Long Suluy on the Kelai River as an exploratory foray aiming to assess the feasibility of a long-term project there. The choice of this village as my destination was influenced by the reports that the inhabitants of this most remote village spend a greater part of the year in forest encampments collecting forest products for trade (Guerreiro 1985; Ring 1968; Sinamjuntak 1967; Suwondo 1981). Sure enough, upon my arrival in the village nearly 90% of the population (approx. 250 individuals; it is just an estimate) were gone collecting or hunting; only older men, women, and some children remained.

As the individual families began gradually returning to the village, I had an opportunity to interview some family members and ask them (among other things) about the resources they were exploiting and the methods involved. It soon became clear that the most important resource harvested by the Punan of Long Suluy was gold powder which was panned from the bottom of the adjacent streams. However, the rise of gold to prominence as the no.1 exchange item was relatively recent development. I learned that until approximately 1992, gaharu wood was the main source of income for the villagers. However, the influx of outsiders and the destructive methods of extracting gaharu which the foreigners brought with them caused the demise of *Aquilaria* trees in the upper Kelai valley.

According to Punan collectors, the *Aquilaria* trees (they call them simply, "gaharu trees" or *pohon gaharu*) are indeed very thinly dispersed throughout the surrounding mountainous terrain. Once a tree is encountered, the first thing the collector does is a general examination of the tree's appearance. The Punan say they can distinguish the appearance of an "ill" tree from the healthy one. The next step is to examine the leaves and the bark on the tree trunk. The specific condition of the leaves, which they describe as shriveled on the edges and dotted with some brownish spots, is thought to be an encouraging sign. A peculiar smell from the bark may also be an important key indicator of the gaharu deposit.

Following this external examination of the tree, the collector will try to have a look at the wood under the bark. Small incisions will be cut on the trunk and then the collector will try to rip off strips of bark in one quick motion. If the bark comes off in unbroken strips, there is a small probability of founding gaharu inside the tree. However, if the bark breaks and feels brittle, chances for success are good. Having taken off a few bark strips, the collector smells the wood inside and checks the color of the sap. At this point, he should be in position to ascertain whether the tree contains any gaharu or not. My informants were very emphatic about the harmlessness of the whole operation. According to them, taking thin bark strips off does no harm to the tree. And if it turns out that gaharu content is not there, the tree is left to recover so that it may produce off-spring and, who knows, at some point in the future it may eventually carry gaharu as well.

3.3 Intensive Means of Extracting Gaharu Wood.

Within the last five years there has been a speedy intensification of extracting gaharu in Borneo mainly because the other primary sources of this product, particularly Burma and Cambodia, have been largely exhausted. With the prices for top quality gaharu (uniformly black color, intense aroma, high content of resin) reaching \$500-\$600 per kilogram, it comes as no surprise that urban entrepreneurs in Indonesia have begun establishing companies which specialize in collecting, processing, and exporting gaharu to lucrative overseas markets.

One of the most critical problems threatening the ecological status of the genus *Aquilaria* in East Kalimantan is the legal confusion over rights of access to this resource, as well as the unclear nature of the laws which are supposed to regulate the extraction of and trade in gaharu. According to the Governor's decision of 1994, all companies seeking to obtain gaharu are allowed to purchase this product from local villagers only; they are not allowed to actively engage in exploitation — i.e., sending search teams of their own is prohibited (Menuntung 1994a; Menuntung 1994b). However, as is usually the case in Indonesia, the written law and the actions which the law is supposed to govern do not converge. There is virtually no supervision of the pharmaceutical companies' conduct in the field. And even if some irregularities are periodically discovered, the patronage of the local political leaders (who themselves pocket part of the profits generated from the sale of gaharu) ensures that no action is taken against the perpetrators.

As a result, it is common knowledge that the largest pharmaceutical company in East Kalimantan (known as CVSDA) which has the license to purchase gaharu

migrants from other islands (Sulawesi, Sumatra, etc.) who for a nominal fee are ready to scour the remotest locations in the province in order to find gaharu (Kondradus 1995; World Wild Fund 1995). The Punan informants I was working with from Long Suluy see two major problems when people of this sort appear in the upriver area. First, there is an immediate conflict resulting from the violation by the outsiders of the customary Punan (unwritten) rights over the territory they inhabit and the resources found therein. However, this is not an unsurmountable problem for the Punan. To be sure, having the foreigners cut and dig all over the forest surrounding the settlements is not an amusing or enjoyable sight. But the Punan are ready to concede that, so long as the METHODS the outsiders use to search for gaharu do not wipe out all the trees in the process. The non-local collectors of gaharu are significantly lacking in knowledge of the forest in general and they possess none of the skills which Punan use to examine the *Aquilaria* trees for gaharu content. The outsiders cannot discern whether *Aquilaria* tree possesses gaharu by observing things such as the shape and color of the leaves, brittleness of the bark, sap smell and color. The most common practice employed in order to compensate for lack of local knowledge is to chainsaw each and every *Aquilaria* tree. By cutting every tree, the collectors eliminate the possibility that they may miss some gaharu deposit by accident. At the same time, however, they effectively destroy all mature stands, thus halting the production of the seeds (regeneration). This obviously threatens the very survival of the *Aquilaria* as a species. In order to illustrate how quickly the destruction of *Aquilaria* trees proceeds, I will again invoke the commentaries of my Punan informants. Within the two-year time span (1992-94), the entire region of the upper Telen River, south of Kelai (see map), has been searched clean by the collectors "for hire". There is no more gaharu to be found there nor will there ever be any to look for in the future — all mature trees have been cut and destroyed. In 1995 the outsiders began to pour into the upper Kelai River, penetrating small tributaries and, as usual, stripping all *Aquilaria* trees. The Punan pleaded with the local administration officials to stop this wasteful frenzy, but to no avail. The problem (in the officials' view) is that any effort to bring the situation under control would require at least partial recognition of Punan land/property rights. The bureaucrats are usually panic-stricken when it comes to giving any rights to the "tribals" (*suku terasing*) because it may set an undesirable precedent.

4. Exploitation of Gaharu — Is It Intrinsically Destructive?

By comparing the means and methods of searching for gaharu wood as practiced by semi-nomadic Punan as well as non-local collectors paid by the city-based pharmaceutical firms, it was my intention to indicate that there may indeed be a way to harvest a fundamentally non-renewable forest product sustainably.

In the section dealing with the biology and ecology of *Aquilaria*, I mentioned that the spatial distribution of the trees is such that only 1-3 can be found within the area of 10 ha. Furthermore, only 1 out of every 10 trees encountered may actually contain gaharu. Considering the Punan methodology of removing only the diseased-looking trees which are almost certain to contain gaharu (and keeping in mind their efforts to examine other trees in a non-harmful way), it follows then that Punan collectors remove only about 1-3 trees per 100 ha, which constitutes approx. 10% of the mature *Aquilaria* stock. The continuation of the *Aquilaria* spp. is thus ensured as the seed producers (i.e., mature trees) are still in place.

The activities of the non-local commercial collectors, however, have radically different consequences. As I have already mentioned, their main objective is to cut all *Aquilaria* trees found in the forest, so as to ensure that no gaharu deposit has been overlooked. This destructive method of extraction compensates for the outsiders' lack of local knowledge of the biology and ecology of gaharu host tree. The indiscriminate cutting of all *Aquilaria* trees results in virtually total destruction of all mature stock, thus threatening the continuance of this species in the region. Although the actual extinction may possibly be averted (very young trees and small saplings are unlikely to be destroyed), the recovery of the trees and the reappearance of the gaharu substance will be a very time-consuming process.

It is my tentative conclusion, therefore, that gaharu, in spite of its dubious status as a NTFP, could be harvested in a sustainable manner. In order to render it a realistic possibility, certain ground-breaking (although in my view fundamental) changes would have to be made, not the least of which would be: a) recognition of Punan land/resources rights; b) requirement that the pharmaceutical companies hire Punan "consultants" who supervise extraction procedures and have the right to forbid the outsiders entry into the areas which have already been harvested. Even if achieved, given the contemporary political climate in Indonesia, such rights would be extremely difficult to uphold. Against all odds, local NGOs are attempting to address these issues by recognizing their regional significance, not just their local impact.

References Cited

- Achmad, S. (Sultan Gunung Tabur)
1979 *Adat Orang di Gunung Tabur*. Yayasan Idayu, Jakarta.
- Allegretti, H.M.

- 1990 "Extractive Reserves: an Alternative for Reconciling Development and Environmental Conservation in Amazonia." In, Anderson, A.B. (Ed.) *Alternatives to Deforestation: Steps Toward Sustainable Use of the Amazonian Rain Forest*. Columbia University Press, NY.
- Anderson, A.B. and Jardim, M.A.G.
1989 "Costs and Benefits of Floodplain Management by Rural Inhabitants in the Amazon Estuary: a Case Study of Acai Palm Production." In Browder, J.O. (ed.), *Fragile Lands of Latin America: Strategies for Sustainable Development*. Westview Press, Boulder, CO.
- Appasamy, P.P.
1993 "Role of non-timber forest products in a subsistence economy: the case of a joint forestry project in India." *Economic Botany* 47(3):258-67.
- Beniwal, B.S.
1989 "Sivical characteristics of *Aquilaria agallocha*." *Indian Forester* 115(1):17-21.
- Bhattacharya, B. et. al.
1952 "On the formation and development of agar in *Aquilaria agallocha*." *Science and Culture* 18(5):240-41.
- Bhishagranta, K.K.
1907 *Sushruta Samhita*. Calcutta, India.
- Bodmer et. al.
1993 "Managing wildlife to conserve Amazonian forests: population biology and economic considerations of game hunting." *Biological Conservation* 50:29-35.
- Burkill, I.H.
1935 *A Dictionary of the Economic Products of the Malay Peninsula*. 2 vols., London, England.
- Chopra, K.
1993 "The value of non-timber forest products: an estimation for tropical deciduous forests in India." *Economic Botany* 47(3):251-57.
- Corner, E.J.H.
1952 *Wayside Trees of Malaya*. Vol.1. Government Printing Office: Singapore.
- DeBeer, J.H. and McDermott, M.J.
1989 *The Economic Value of Non-Timber Forest Products in Southeast Asia with an Emphasis on Indonesia, Malaysia, and Thai land*. Netherlands Committee for IUCN, Amsterdam.
- Dixon, A.H. et. al.
1991 *From Forest to Market: a Feasibility Study of the Development of Selected Non-Timber Forest Products from Borneo for the U.S. Market*. Harvard Business School, Cambridge, MA.
- Fearnside, P.M.
1989 "Extractive reserves in Brazilian Amazonia." *BioScience* 39(6):387-93.
- Fong, F.W.
1992. "Perspectives for sustainable resource utilization and management of Nipa vegetation." *Economic Botany* 46(1):45-54.
- Gianno, R.
1986 "The exploitation of resinous products in a lowland Malayan rain forest." *Wallaceana* 43:3-6.
- Godoy, R.R. et. al.
1993 "A method for the economic valuation of non-timber tropical forest products." *Economic Botany* 47:220-233.
- Gradwohl, J. and Greenberg, R.
1988 *Saving the Tropical Forests*. Earthscan Publications Ltd., London, England.
- Guerreiro, A.L.
1985 "An ethnological survey of the Kelai river area, Kabupaten Berau, East Kalimantan." *Borneo Research Bulletin* 18:106-120.
- Harini, S.R.
1990 "Ethnobotany of the Javanese incense." *Economic Botany* 44:413-16.
- Hou, D.
1960 "Thymeleaceae." *Flora Malesiana*, series 1, vol.6.

- Humas (Pemerintah daerah).
1992 *Monografi Daerah Tingkat II Berau Kalimantan Timur, Tahun 1991-1992*. Tanjung Redeb, Berau.
- Jessup, T.C.
1983 *Forest Exploitation by Shifting Cultivators in Borneo (Kalimantan)*, PhD dissertation, Rutgers University, NJ.
- Kahn, F.
1988 "Ecology of economically important palms in Peruvian Amazonia." *Advances in Economic Botany* 6:42-49.
- Kondradus, B.
1995 *Jaringan Pemasaran Gaharu di Kecamatan Long Pujungan dan kawasan Bahau*. MA thesis, Culture & Conservation in East Kalimantan.
- Menuntung*
1994a. "Inzin gaharu tidak jelas: heboh, setelah hilangnya 16 pekereja CV SDA." *August* 7, 1994.
- Menuntung*
1994b. "Mencari gaharu di pedalaman Kaltim: bak memburu 'kayu siluman'." *August* 15, 1994.
- Miller, J.I.
1969 *The Spice Trade of the Roman Empire: B.C. to A.D. 641*. Clarendon Press, Oxford, England.
- Nepstad, D.C. et. al.
1992 "Biotic impoverishment of Amazonian forests by rubber tappers, loggers, and cattle ranchers." *Advances in Economic Botany* 9:1-14.
- Nurhayati, T.
1988 "Siberut in the grip of gaharu fever." *Voice of Nature* (no vol. and pp. available).
- Padoch, C.J.
1988 "Aguaje (*Mauritia flexuosa*) in the economy of Iquitos, Peru." *Advances in Economic Botany* 6:214-24.
- Panayotou, T. and Ashton, P.S.
1992 *Not by Timber Alone: Economics and Ecology for Sustaining Tropical Forests*. Island Press, Covelo, CA.
- Paoli, D. Gary, Leighton, Mark, and Peart, David
1993 "Economic ecology of gaharu wood (*Aquilaria* spp.) In Gunung Palung National Park, West Kalimantan, Indonesia: valuation of extraction and residual population." Unpublished manuscript.
- Peluso, N.L.
1983 *Markets or Merchants?: the East Kalimantan Forest Products Trade in Historical Perspective*. MA. Cornell University, NY.
- Peluso, N.L.
1992a. "The rattan trade in East Kalimantan, Indonesia." *Advances in Economic Botany* 9:115-27.
- Peluso, N.L.
1992b. "The ironwood problem: (mis)management and development of an extractive rainforest product." *Conservation Biology* 6(2):210-19.
- Peters, C.M. et. al.
1989a. "Valuation of an Amazonian rainforest." *Nature* 339:655-56.
- Peters, C.M. et. al.
1989b "Oligarchic forests of economic plants in Amazonia: utilization and conservation of an important tropical resource." *Conservation Biology* 3(4):341-49.
- Pinedo-Vasquez, M.D. et al.
1990 "Use values of tree species in a communal forest reserve in northeast Peru." *Conservation Biology* 4(4):405-15.
- Plotkin, M.J. and Famolare, L.M.
1992 *Sustainable Harvest and Marketing of Rain Forest Products*. Island Press, Washington, D.C.
- Prance, G.T. et al.
1987 "Quantitative ethnobotany and the case for conservation in Amazonia." *Conservation Biology* 1:296-310.
- Ring, M. Sulaiman
1968 "Hasil Survey Terhadap Suku Punan." *Djami'ah* 1:1-53.

- Saw, L.G. et. al.
1991 "Fruit trees in a Malayan rain forest." *Royal Economic Botany* 45(1):120-36.
- Schwartzman, S.
1989 "Extractive reserves: the rubber tappers' strategy for sustainable use of the Amazon forests." In, Browder, J.O. (ed.), *Frangible Lands and Latin America: Strategies for Sustainable Development*. Westview Press, Boulder, CO.
- Sidiyasa, K. et. al.
1986 "Exploration and study of regeneration of gaharu producing species in Kintap forest region, South Kalimantan." *Buletin Simanjuntak*, M.
1967 *Masyarakat Punan Ketjamatan Kelaji Kabupaten Berau Propinsi Kalimantan*. Samarinda, Skripsi APDN.
- Suwondo, B.
1981 *Cerita Rakyat Daerah Kalimantan Timur*. Departamen Pendidikan dan Kebudayaan, Proyek Inventarisasi dan Dokumentasi Kebudayaan Daerah.
- Vasquez, R. and Gentry, A.H.
1989 "Use and misuse of forest-harvested fruits in the Iquitos area." *Conservation Biology* 3(4):350-62.
- Walchren, E.W.F., van
1907 "Eene reis naar de bovenstrekken van Boeloengan (Midden Borneo)" pp. 755-844. Reading translation in English by dr. Cornelia N. Moore, transcribed and edited by Rajindra Puri.
- Wang, Gungwu
1958 The Nanhai trade: a study of the early history of Chinese trade in the South China Sea." *Journal of the Malaysian Branch of the Royal Asiatic Society* 31(2):1-135.
- Wheatley, P. 1959
Geographical notes on some commodities involved in Sung maritime trade." *Journal of the Malaysian Branch of the Asiatic Society* 32(2)5-139.
- World Wild Fund
1995 *Pemungutan Gaharu di Apau Kayan: Pemasalahan dan Konteksnya*. Jakarta.