ISSN : 0917-415X DOI:10.3759/tropics.MS15-16

TROPICS Vol. 25 (4) 139-146 Issued March 1, 2017

ORIGINAL ARTICLE

Sustainable Harvesting and Conservation of Agarwood: A Case Study from the Upper Baram River in Sarawak, Malaysia

Kentaro Kanazawa[1*]

[1] Institute of Humanities, Shinshu University, 3-1-1 Asahi, Matsumoto 390-8621, Japan
* Corresponding author: kanazawa@shinshu-u.ac.jp

Received: November 10, 2015 Accepted: September 6, 2016 J-STAGE Advance published date: January 5, 2017

ABSTRACT Agarwood is one of the most valuable non-timber forest products harvested from the heart of the mountains of Southeast Asian tropical rain forests. Some species of trees in the genus *Aquilaria* (Thymelaeaceae) accumulate resins in parts of their trunks. Agarwood has a long history as a trade good, although ecological data and economic assessments regarding agarwood harvesting in natural habitats are lacking. The author performed field surveys in the upper reaches of the Baram River in Sarawak, Malaysia, to assess the possibility of harvesting natural agarwood sustainably. In 2004, the habitat density of *Aquilaria beccariana* around village L was less than one tree per ha, and only relatively mature trees produced resins in their trunks. The introduction of commercial logging and hill rice cultivation damages the habitat of *A. beccariana*. Thus, the conservation of primary forests is essential for natural agarwood harvesting. The local Penan people only harvest the portions of the trees where resins accumulate, which allows the trees to survive. However, exploitative agarwood harvesting has begun in this area since the early 2010s, as a result of intrusions by outsiders. Thus, one cannot assume that all agarwood harvesting in Sarawak is being conducted sustainably. Meanwhile, in areas with no traces of outside intruders, the number of mature agarwood-producing trees has been maintained, suggesting that the method of agarwood harvesting used by the villagers is sustainable. To ensure that agarwood harvesting is sustainable, traceability that is based on more strictly defined and more detailed information regarding all of the steps in the agarwood supply chain is required.

Key words: Agarwood, non-timber forest product, primary forest, sustainable harvest, Sarawak

INTRODUCTION

The purpose of this study was to characterize the conditions for the sustainable harvesting of natural agarwood, and also to investigate its conservation. Agarwood is a forest product that is found in rainforests in East India and throughout Southeast Asia. Some species of trees in the genus *Aquilaria* (Thymelaeaceae) accumulate resins in parts of their trunks. The resin, which forms aromatic nodules, is called *agar* or *gaharu* (in Malaysia and Indonesia). It is burned or heated to release a subtle, but profound, fragrance. In Islam and Buddhism, agarwood in the form of wood chips or incense is used to purify spaces used for religious ceremonies. Agarwood is also used as a Chinese herbal medicine for asthma and gastrointestinal fragility because of its calming effect. In Japan, the incense ceremony using agarwood became established as *Koh-doh* in the Muromachi era (1336-1573), and it is still performed today by enthusiasts (Morita 1992). Agarwood had a long history as a trade good and it was first imported into China around the first century A.D. (Dunn 1975). Hong Kong, as its Chinese characters reveal, flourished as an entrepôt port dealing in aromatic woods. Agarwood is one of the most expensive forest products in the world. The price of agarwood sold as wood pieces or small chips varies with quality (grade). Long-established retail shops in Kyoto sell the best agarwood for US\$250 g^{-1}. Thus, it is much more expensive than pure gold or platinum.

The preceding studies are divided into two types. One describes the distribution characteristics of agarwood in nature reserves such as national parks: for example, the study of population dynamics of agarwood in the Pasoh forest reserve, Malaysia (LaFrankie 1994) and the distribution characteristics of agarwood in West Kalimantan in Gunung Palung National Park, Indonesia (Paoli et al. 2001). Why were the preceding surveys limited to nature reserves? For the most part, areas of primary forest no longer exist outside of such reserves. Even if a forest is not subjected to commercial logging, forest access is difficult in most cases. The physical burden of conducting a field survey on such steep mountain terrain is significant, and carries risk of injury.

The other type of study is based on interviews of agarwood harvesters. Yamada (1995), in a broad-based exploration and interviews with villagers and agarwood dealers in Borneo, argued that the amount and quality of agarwood resources have decreased. According to interviews with agarwood harvesters in Vietnam, they repeatedly embark on harvesting trips over several weeks in groups of 2−4 people (Tran et al. 2003). Interview surveys of harvesters in the Kayan Mentarang National Park and the surrounding area in East Kalimantan, Indonesia, indicate that teachers and governmental employees who participate in agarwood harvesting leave their jobs behind (Momberg et al. 1997). Forest resources located far from the residential areas are regarded as open access resources (Wollenberg 2001). It is said that inexperienced outsiders attempt to cash in on what they perceive as open access to resources in East Kalimantan, Indonesia (Donovan and Puri 2004). The current Indonesian trade in agarwood is not sustainable (Soehartono and Newton 2002), and in the forests of Laos, foreign groups without legal permission are engaged in harvesting activities (Jensen and Meilby 2010).

This study focuses on the case of natural agarwood harvesting in a forest that is not part of a nature reserve. The forest still encompasses a primary forest because the local Penan people have used protests to protect it from commercial logging. Survey data in the remaining primary forest is not only important for research purposes, it should provide valuable suggestions for improving forest management policies. The purposes of the field survey, were as follows: (1) to identify the distribution characteristics of agarwood in primary forest areas where the local people live; (2) to compare the distribution characteristics under different land use patterns; (3) to identify the methods by which local people harvest agarwood; (4) to determine the amount of income the villagers receive from agarwood harvesting; and (5) to record changes in a 10-year period and their effect on the distribution and harvesting of natural agarwood.

MATERIALS AND METHODS

The location for this field survey was village L, a Penan village in the upper reaches of the Baram River in Sarawak, Malaysia (Fig. 1). It should be noted that the author employs a notation that prevents the identification of the village and the harvest location. Village L was the most suitable village in which to examine the relationships between various land use patterns and agarwood resources. In the last quarter of a century, commercial logging in Sarawak has reached to deepest parts of the forest near the border with Indonesia; as a result, little primary forest

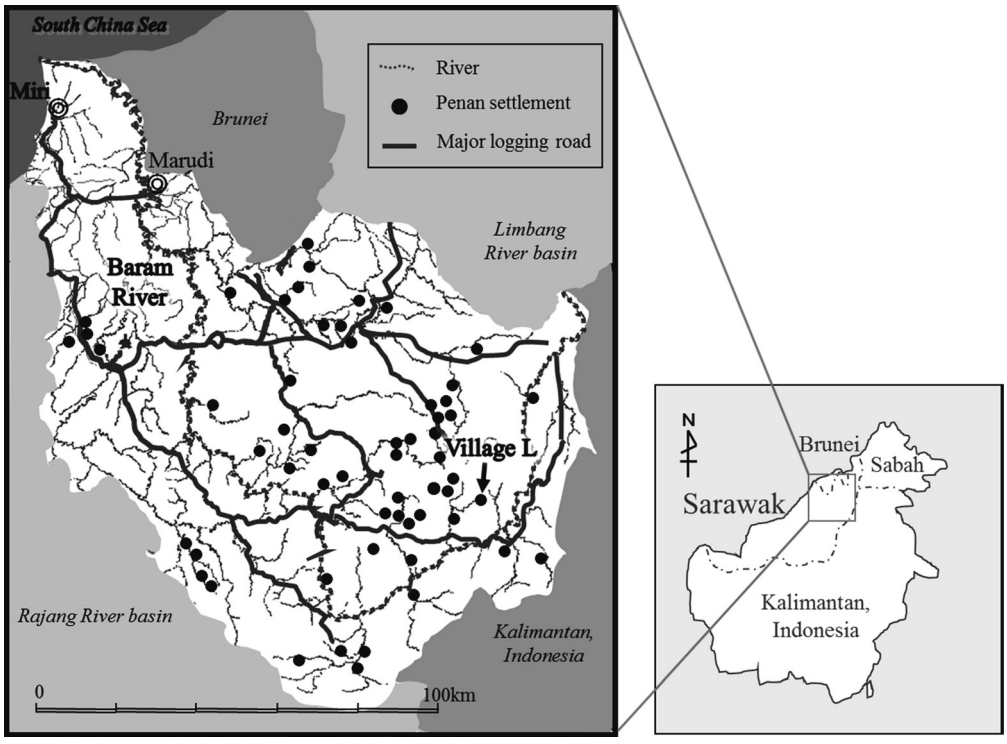

Fig. 1. Map of the Baram River basin

remains, except nature reserves. The Baram River basin is the last remaining area of primary forest. Village L has the largest primary forest area among the Penan settlements in this area. However, some parts of the forest have been commercially logged.

The Penan people have traditionally used the area around village L which comprises approximately 50,000 ha (30,000 ha of primary forest and 20,000 ha of secondary forest). However, the government has not allowed the Penan to engage in any customary land use thus far. In 2011, the Penan in the region announced plans called "Tana' Pengida Pengurip Penan" (TPPP) in the Penan language, which translates as "the Penan Peace Park" (Penan, 2011). The objectives of the TPPP are to ensure indigenous rights and self-determination, to respect and protect the ecosystem, and to promote economic development. The economic development program aims to ensure a source of cash income via the commercial development of non-timber forest products (NTFPs).

To reach village L, one must drive along a logging road from Miri, a coastal city, for 10 hours and then walk for 2 hours (Fig. 2). Primary forest, without any commercial logging activity, surrounds the village. The village comprises 28 households and 118 people. People in village L hunt with blowpipes and gather sago starch and other forest products. The Penan people of village L established settlements and started hill rice farming in the 1960 s. They were taught agricultural practices by their relatives living nearby, who learned from farming neighbors such as the Kelabit and Saban. The average hill rice area per household was 2.33 acres, as determined by the author's survey in 1998.

The information in this study was based on observation and surveys, each lasting 7−21 days, which were conducted by the author in September 1998, in September 2002, in August 2004, and in March 2014 at the study site. When performing the surveys in August 2004 and March 2014, the author asked two male villagers who had experience with harvesting agarwood to travel to the agarwood habitat and we recorded the presence any agarwood stands.

Four survey sites were chosen, each in river basins of the primary forest, and the villagers sometimes go to harvest agarwood from these sites. First, we walked for 90 ha along the T, B, D, and L rivers to examine the distribution of agarwood-producing trees. Survey times at the T, B, D, and L rivers were 9, 4, 9, and 5 hours, respectively. The author tried to use the Global Positioning System to

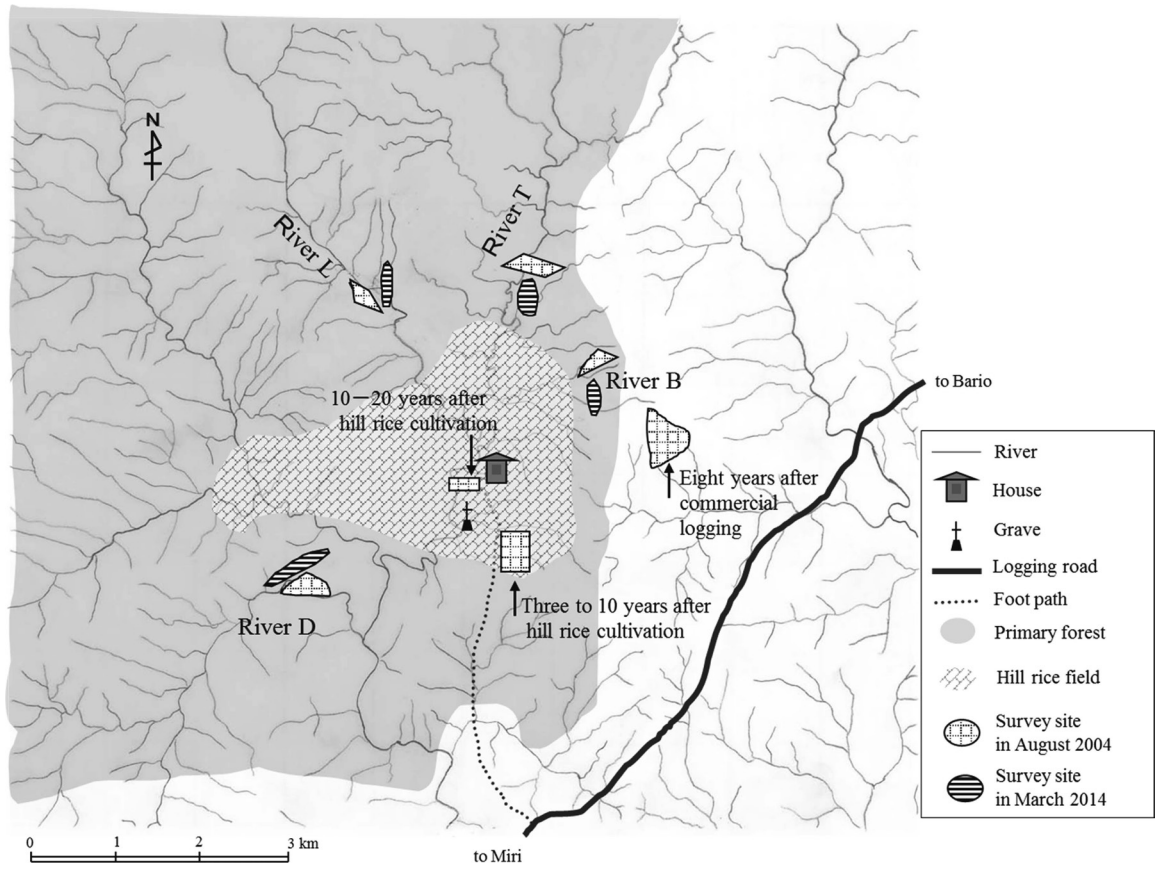

Fig. 2. The study site

understand the survey range. However, it was not possible to use the same survey sites from 2004 to 2014 because GPS coordinates are difficult to establish within the thick forest. We examined areas of equivalent size in the same river basin while finding canopy gaps through which a GPS signal can be received. For comparison, we performed the same survey in 50 ha of secondary forests 8 years after commercial logging, in 40 ha of secondary forests 3−10 years after hill rice cultivation, and in 10 ha of secondary forests 10−20 years after hill rice cultivation, and survey times at each spot were 12, 10, and 3 hours, respectively. The author took photos and kept records of all the agarwood-producing trees they found. The author used an ultrasonic hypsometer and a tape measure to estimate the heights of trees and to determine their diameter. The results of the surveys were cross-checked with other villagers, including the village head.

RESULTS

Harvesting Method

While there are four species of agarwood in Sarawak (*Aquilaria beccariana*, *Aquilaria malaccensis*, *Aquilaria microcarpa*, and *Aetoxylon sympetalum* (Sarawak Forestry Corporation, 2015)), only *A. beccariana* could be surveyed around the village. *A. beccariana* is called *gaharu ba*, meaning "river agarwood." There is another type of agarwood in a location away from the village. It is *A. microcarpa*, which is called *gaharu tokong* (meaning "mountain agarwood"). Generally, *gaharu tokong* trees are larger than *gaharu ba* trees, but the leaves of *gaharu ba* trees are larger than those of *gaharu tokong* trees. The *gaharu tokong* and *gaharu ba* trees are important for the villagers' livelihoods. *Gaharu tokong* trees are of higher quality than *gaharu ba* trees, but it is necessary to walk through the forest for a longer time to harvest the former.

Among the villagers, only adult males engage in agarwood harvesting. In the surveyed village, day trips for harvesting were common. Usually one or two people from village L go out looking for agarwood. In cases in which two people search for agarwood, siblings or other relatives are paired together. Physical fitness is essential to traverse steep mountains and valleys, and patience is needed to endure mosquitoes and leeches along the way.

They recognize whether agarwood stands are present in a given basin though their experience. However, they do not memorize the exact location of each and every agarwood stand. They strike out from their point of departure, fanning out left and right to cover an area of about 10 m, and climb the slopes. After they walk for a while, they move either left or right and continue to search in meandering way. When the Penan look for agarwood in the forest, they examine fallen leaves and tree bark. Upon finding a fallen leaf, they can immediately find the nearby tree. The shape of the leaf has a sharp tip that is similar to a slim oval coin. Even if the green part of the leaf dies, the leaf vein is preserved. It cannot be determined whether agarwood is available from the quality (size or withered condition) of the leaf. The Penan make a small cut in the tree bark and if they find resins, they use an ax or a knife to cut out only the part where resin has accumulated. Only relatively mature trees produce resin, and if the trees are not cut down, they can accumulate resin again. The harvesting methods are the same for *gaharu ba* and *gaharu tokong* trees.

When the Penan harvest agarwood, they use the word *minut*. *Minut* means 'using carefully little by little'. "*Amé minut telako.*" translates as 'We harvest agarwood in a sustainable way.' *Nguburah* means consuming thoughtlessly. For example, "*Irah jah nguburah tebeng telako.*" translates as 'Outsiders cut all the agarwood as soon as they find it'. Additionally, an adopted setup is called *molong*, which means that resources such as agarwood, are left for the next generation to harvest. "*Pu'un oro siteu. Sin pu'un kelunan molong telako iteu.*" translates as 'There is a sign here; it means there someone is claiming this agarwood for use in the future'. Thus, these often used expressions encourage people to use forest resources sustainably.

Agarwood Distribution

The author recorded 72 agarwood-producing trees in a total of 90 ha of primary forest around village L in 2004 (Table 1). They were all *A. beccariana*. The *A. beccariana* distribution densities of the T, B, D, and L rivers were 0.67, 1.41, 0.41, and 1.38 trees ha^{-1}, respectively. The average tree height was 9.1 m, and it ranged from 0.3 to 23.8 m. The average diameter 10 cm above the ground was 11.4 cm, and it ranged from 1.3 to 30.0 cm. Among them, 11 trees had been cut with an ax. These trees were believed to have contained some amount of resin. In contrast, as Table 2 shows, in approximately 50 ha of the forest where 8 years have passed since the end of commercial logging activities, there were only two *A. beccariana* trees. The commercial logging area is remarkably large compared with the agricultural fields which the local people use for subsistence. When heavy industrial machines enter the

Table 1. Distribution density of *A. beccariana* trees around rivers in 2004

Location	Area (ha)	No. of trees	Distribution density (ha^{-1})
Around river T	30	20	0.67
Around river B	12	17	1.41
Around river C	32	13	0.41
Around river L	16	22	1.38
Total	90	72	0.80

Source: Observation and surveys by the author.

Table 2. Distribution density of *A. beccariana* trees in secondary forests in 2014

Type of secondary forest	Area (ha)	No. of trees	Distribution density (ha^{-1})
Eight years after commercial logging	50	2	0.04
Three to 10 years after hill rice cultivation	40	0	0.00
10−20 years after hill rice cultivation	10	1	0.10

Source: Observation and surveys by the author.

Table 3. Distribution density of *A. beccariana* trees around rivers in 2014

Location	Area (ha)	No. of trees	Distribution density (ha^{-1})
Around river T	30	43	1.43
Around river B	12	64	5.33
Around river C	32	40	1.25
Around river L	16	23	1.44
Total	90	170	1.89

Source: Observation and surveys by the author.

forest, they greatly damage the surroundings, even when used in a selective logging operation. There were no agarwood-producing trees in approximately 40 ha of secondary forests 3−10 years after hill rice cultivation because the local Penan usually cut down and burn all the trees during hill rice farming. There was, however, one *A. beccariana* tree that was 12.6 m tall and 21.6 cm in diameter, in approximately 10 ha of fallow forests 10−20 years after hill rice cultivation.

The distribution of agarwood had markedly changed in 2014, compared with that in 2004. In 2014, in a total of 90 ha of the same basin around the village, 170 agarwood-producing trees were recorded (Table 3). It was supposed that the same river basin was the same growing condition. The distribution densities of agarwood-producing trees on the T, B, D, and L rivers were 1.43, 5.33, 1.25, and 1.44 trees ha^{-1}, respectively. The average tree height was 5.2 m, and it ranged from 0.2 to 22.0 m. The average diameter was 4.6 cm, and it ranged from 0.2 to 34.4 cm, the latter of which was less than half that in 2004.

Along the T, B, and D rivers, there was a decrease in the number of trees greater than 15 cm in diameter (Tables 4 and 5). The number of trees of similar size along the L river increased from two to four. In contrast, seedlings less than 50 cm in height increased markedly from 0 to 8, 1 to 15, and 0 to 5 ha^{-1} along the T, B and D rivers, respectively. Saplings greater than 50 cm in height and less than 15 cm in diameter also increased from 13 to 30, 7 to 42, and 10 to 34 ha^{-1} along the T, B and D rivers, respectively. By interviewing the villagers, it was determined that the agarwood-producing trees had been cut down by outside intruders. Outsiders had entered the forest via the logging road, without obtaining permission from the village head. Based on the number and size of temporary dwellings left behind, it was estimated that approximately 20 poachers had pitched their camp along the B river. As a result of exploitative agarwood harvesting, agarwood seeds are sprouting in the resulting gap. Only the area in the vicinity of river L escaped destructive harvesting because of its distance from the logging road. Along the T, B, and D rivers, but not the L river, the number of large mature trees decreased, while the numbers of seedlings and saplings

Table 4. Number of seedlings, saplings and mature *A. beccariana* trees around rivers in 2004

Tree size	River T	River B	River D	River L
Seedlings (＜50 cm height)	0	1	0	0
Saplings (＞50 cm height and＜15 cm DBH)	13	7	10	20
Mature trees (＞15 cm DBH)	7	9	3	2

Source: Observation and surveys by the author.

Table 5. Number of seedlings, saplings and mature *A. beccariana* trees around rivers in 2014

Tree size	River T	River B	River D	River L
Seedlings (＜50 cm height)	8	15	5	1
Saplings (＞50 cm height and＜15 cm DBH)	30	42	34	18
Mature trees (＞15 cm DBH)	5	7	1	4

Source: Observation and surveys by the author.

Table 6. Villagers' 1-month income from agarwood (August 2004)

Name	Working days	Quantitiy (kg)	Quality	Income (MYR)
Mr. G	5	0.15	Grade 3	90
Mr. K	20	1.60	Grade 3	1,040
Mr. S	20	0.10	Grade 1	200
		3.00	Grade 4	15

Source: Interview and observation by the author.

increased. To prevent intrusion by outsiders, the village head sent a notification statement to neighboring villages and called for patrols by his villagers.

Income for Villagers

During the month of August 2004, three villagers collected 4.35 kg of agarwood from an estimated 1,350 ha of forest; no other people looked for agarwood during this period. The three men, having knowledge of the forest and physical strength, were all adult males. They did not use the agarwood for themselves. According to the prices offered by local brokers (first grade, MYR 2,000 kg^{-1}; second grade, MYR 1,500 kg^{-1}; third grade, MYR 650 kg^{-1}; fourth grade, MYR 50 kg^{-1}; and fifth grade, MYR 3 kg^{-1}), the agarwood that was collected by the men was worth MYR 1,345 (US $366) (Table 6). According to the villagers, the income earned from agarwood by the three villagers exceeds that of handicrafts made of rattan, as well as other cash income sources. The local broker comes to purchase agarwood once per month. He mentioned that it was important to maintain a relationship of trust with the Penan. As other brokers sometimes come from Marudi and Miri, the Penan have opportunities to negotiate the price with them. At the time of the survey in March 2014, there were no villagers with stocks of agarwood.

DISCUSSION

According to the International Union for Conservation of Nature's Red List of Threatened Species, *Aquilaria crassna* and *Aquilaria rostrata* are listed as critically endangered species, and seven other species are listed as vulnerable species. *A. beccariana*, which was surveyed in village L, has also been listed as a vulnerable species. In 2004, all *Aquilaria* species were also subjected to trade controls under the Convention on International Trade in Endangered Species of Wild Fauna and Flora appendix II (Barden et al. 2000, UNEP-WCMC 2015). Indonesia and Malaysia have export quotas for agarwood. As of 2016, these are 600,000 kg for Indonesia, 150,000 kg for the Malaysian Peninsula and Sabah, and 5,000 kg for Sarawak. However, nothing is indicated about the scientific basis for each quota or the domestic distribution process.

The quality of the product from agarwood plantations is still far below that from natural forests, although

cultivation technology is developing. Products from agarwood plantations are restricted mainly to applications involving oil. There is still a strong demand for high-quality agarwood, and practices that ensure sustainable agarwood harvesting and natural agarwood conservation are urgently needed.

LaFrankie (1994) found a population of *A. malaccensis* trees, with the density of 2.5 trees ha^{-1}, in a plot of the Pasoh Forest Reserve, and 125 of the trees had a diameter at breast height (DBH) greater than 1 cm. In Kayan Mentarang National Park, Paoli et al. (2001) found a few mature *Aquilaria malaccensis* trees (>20 cm DBH), ranging from 0.16 to 0.32 stems ha^{-1}. In this study, we found 0.8 agarwood-producing trees ha^{-1} in 2004. Compared with the preceding studies in nature reserves, this is a mid-range density.

When land use practices such as commercial logging or hill rice cultivation are introduced, the habitat of agarwood is destroyed. In Sarawak, timber is produced via the selective logging method, which takes into account the trunk diameter and types of trees. However, even selective logging practices damage surrounding vegetation. The harvesting of natural agarwood depends on the conservation of primary forests. It is also desirable to investigate the ecological conditions of the primary forest in which agarwood-producing trees grow and how the resin is formed.

Previous studies based on interviews with groups of harvesters indicate that there was a competitive relationship between those engaged in harvesting activities of each region, and that tree-harvesting efficiency was valued over sustainability. It is reported that in Indonesia, trees are harvested irrespective of whether they contain resin (Soehartono and Newton 2001, 2002). In contrast, in village L, the Penan people all harvested agarwood from the area around their village. The villagers do not cut down the entire agarwood-producing tree; they only cut out parts of the tree where resin has accumulated, which allows the tree to survive. However, exploitative agarwood harvesting has begun in this area too, as a result of intrusions by outsiders. In contrast, in areas with no traces of outside intruders, the number of mature agarwood-producing trees has been maintained, suggesting that the method of agarwood harvesting used by the Penan in village L is sustainable.

In forestry, timber has been recognized as the major forest product, while other products are minor. However, it was only a century ago that people started focusing on timber in the rainforest. During the period that Sarawak was under the colonial rule of the "White Rajahs" of the English Brooke family, markets for barter called "*tamu*" were held deep within the interior. The elders of the Penan people still remember that custom to this day. The Penan people of that age maintained a nomadic or semi-nomadic lifestyle, while remaining able to voluntarily sell products, such as rattan and resin, which they collected from the forest. Government officials also attended *tamu*, weighed the forest products the Penan people had brought from the forest, and estimated prices. Furthermore, the officials checked whether the prices of the goods that the farming neighbors had brought from town were appropriate. The government balanced the interests of the Penan and the neighbors, and fulfilled the role of overseeing fair trade in the market. To the Penan, *tamu* were valuable sources of income and information regarding the outside world. However, with the advance of commercial logging in the 1970 s, the tradition of *tamu* vanished (Langub 1984). Currently, the Penan people are attempting to reach an agreement with the Sarawak state government regarding the proposed TPPP. As the memory of *tamu* lingers, they are seeking to once again develop NTFPs as a source of income.

The collection of forest products, such as agarwood, which do not necessarily require that forests be logged, will ensure that a certain level of productivity can be sustained. Compared with timber, NTFPs, as trading goods, have higher values. These products are also traded at much fairer prices. As a result, profits have been returned to local harvesters. It would not be appropriate to deal with the place of origin of NTFPs at the national level today. What is required is a traceability that is based on more strictly defined and more detailed information regarding all of the steps in the agarwood supply chain, as well as the subsequent distribution process.

ACKNOWLEDGEMENTS In planning this study, the author received advice from Sarawak Development Institute and Institute of East Asian Studies, Universiti Malaysia Sarawak. During the field work, the L villagers hosted me. The author wishes to thank the anonymous reviewers for providing useful comments. This work was supported by the Japan Society for the Promotion of Science (KAKENHI) (grant numbers JP25550103 and JP25300045).

REFERENCE

Barden A. Awang NA, Mulliken T, Song M. 2000. *Heart of the matter: Agarwood use and trade and CITES implementation for Aquilaria malaccensis*. TRAFFIC International, Cambridge, UK.

Donovan, DG, Puri RK. 2004. Learning from traditional knowledge of non-timber forest products: Penan Benalui and the autoecology of *Aquilaria* in Indonesian Borneo. *Ecology and Society* 9 (3): 3.

Dunn FL. 1975. *Rainforest collectors and traders: A case study of resource utilization in modern and ancient Malaya*. Monographs of the Malayan branch of the Royal Asian Society 5. MBRAS, Kuala Lumpur.

Jensen A, Meilby H. 2010. Returns from harvesting a commercial non-timber forest product and particular characteristics of harvesters and their strategies: *Aquilaria crassna* and agarwood in Lao PDR, *Economic Botany* 64: 34−45.

LaFrankie JV. 1994. Population dynamics of some tropical trees that yield non-timber forest products. *Economic Botany* 48: 301−309.

Langub J. 1984. Tamu: Barter trade between Penan and their neighbours, *Sarawak Gazette* 558 (1485): 11−15.

Momberg F, Puri R, Jessup T. 1997. Extractivism and extractive reserves in the Kayan Mentarang National Park: Is gaharu a sustainably manageable resource? *The people and plants of Kayan Mentarang*. World Wide Fund for Nature Indonesia program, London: 165−180.

Morita K. 1992. *The book of incense: Enjoying the traditional art of Japanese scents*. Kodansha, Tokyo.

Paoli GD, Peart DR, Leighton M, Samsoedin I. 2001. An ecological and economic assessment of the nontimber forest product gaharu wood in Gunung Palung National Park, West Kalimantan, Indonesia. *Conservation Biology* 15: 1721−1732.

Penan. 2011. *The Penan Peace Park: Penans self-determining for the benefits of all*. http://www.penanpeacepark.org/resources/2012_Penan_Peace_Park_Proposal_English.pdf (cited April 19, 2014)

Sarawak Forestry Corporation. 2015. *Protected plants*. http://www.sarawakforestry.com/htm/snp-bc-pp.html (cited August 19, 2015)

Soehartono T, Newton AC. 2001. Conservation and sustainable use of tropical trees in the genus *Aquilaria* II: The impact of gaharu harvesting in Indonesia. *Biological Conservation*. 97: 29−41.

Soehartono T, Newton AC. 2002. The gaharu trade in Indonesia: Is it sustainable? *Economic Botany* 56 (3): 271−284.

Tran QL, Tran QK Kouda K, Ngyuyen NT, Maruyama Y, Saiki I, Koda S. 2003. A survey in agarwood in Vietnam, *Journal of Traditional Medicine* 20:124−131.

UNEP-WCMC. 2015. *Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendices I, II, III*. http://www.cites.org/eng/app/appendices.php (cited August 21, 2015).

Wollenberg EK. 2001. Incentive for collecting gaharu (fungal-infected wood of *Aquilaria* spp.; *Thymelaeaceae*) in East Kalimantan. *Economic Botany* 55: 444−456.

Yamada I. 1995. Aloeswood forest and the maritime world, *Southeast Asian Studies* 33: 463−468.