

Conservation Status of Agarwood-Producing Species (*Gyrinops versteegii*) in Indonesia

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Abstract. *Aquilaria malaccensis* and *Gyrinops versteegii* are agarwood producing plant species that is widely used because of its fragrance. *Gyrinops versteegii* has not been much cultivated and along with the decreasing population of *G. versteegii* in its natural habitat. This study aimed to assess scarcity status of *Gyrinops versteegii* based on distribution records from both herbarium and field exploration to assist the formulation of its conservation policy. Distribution data were obtained from online database and also from field exploration in Lombok, Sumbawa, and Flores Islands to obtain the population information. Area of Occupancy (AOO) and Extent of Occurrence (EOO) were calculated using GeoCAT (Geospatial Conservation Assessment Tool) and IUCN status recommendation was discussed. The estimated EOO was 868,422,919 km², exceeding the value required for the threatened category. Based on EOO, it is included in the Least Concern (LC) category, but the EOO covers a large area of the ocean so the AOO was 116 km² as meets criterion B (AOO < 500 km²). It can be categorized into endangered (EN). Population data and conservation status of *G. versteegii* are very important to provide recommendations on the quota wild-harvesting of agarwood by stakeholders.

Key words: conservation; agarwood; *Gyrinops*; geocat; Flores

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INTRODUCTION

Agarwood, likewise sandalwood is a forest product that is widely used because of its fragrance. Many think that agarwood and sandalwood are produced from the same plant (Isnaini, 2008). Sandalwood is produced from sandalwood trees (*Santalum album*) from the Santalaceae family, while agarwood is a non-timber forest product produced from several tree species from several genera of the Thymelaeaceae family (Karlinasari et al., 2015). Agarwood is a resin or a kind of sap that is produced from some infected tree species (agarwood producer). Agarwood which is also widely known as sapwood, karas, mengaras, alim, rakes, sigsigi, gaharu, aloeswood, oud, eaglewood and others, has long been used in traditional Chinese medicine (Barden et al., 2000). Various types of agarwood are grown in Indonesia. It is known that there are about 26 species from seven genera that grow in natural forests, namely *Aetoxylon*, *Aquilaria*, *Enkleia*, *Gonystylus*, *Gyrinops*, *Phaleria* and *Wikstroemia*. Of the seven genera, the *Aquilaria*, *Gyrinops*, and *Gonystylus* are the most utilized genera (Susilo et al., 2014). One of them that will be discussed in this paper is the *Gyrinops versteegii*. It is a tree that can reach up to 10 m in height, 25-30 cm in diameter, and

has various leaf morphologies (Surata & Soenarno, 2011).

Aquilaria filaria and *Aquilaria malaccensis* have been widely known by the public and have been widely cultivated. In the IUCN Red list, *Aquilaria malaccensis* is included in the critically endangered (CR) category (Harvey-Brown, 2018). On the other hand, *Gyrinops versteegii* is starting to be sought after as a type of agarwood producer other than *Aquilaria*. Agarwood in nature has a very high market demand, interest in natural agarwood has resulted in natural agarwood stocks being threatened with extinction. Ideally, the agarwood harvested is agarwood that produces gubal, but in the real condition, whatever agarwood trees are still cut down. This existence made the parent trees in nature limited and the seedling rare too. It has not been much cultivated and along with the decreasing natural *G. versteegii* in its habitat, causing concern about the future of this species.

Based on Indonesian Secretariate of Biodiversity Scientific Authority the quota for wild collecting of *Gyrinops* sp. in Papua Province in 2019 is 750,000 kg and in NTT Province the proposal for 2021 is proposed for 100 kg (personal communication). However, on the other hand, efforts and studies to find out the current condition of the distribution and population of *G. versteegii* are still very rarely

carried out, let alone to know the updating of its conservation status from field data. The populations recorded from Lesser Sunda Island, especially Western Sumba, Alor Island, Lombok Island, and Flores Island, to Sulawesi, Mollucas, and Papua were reported to decline continuously because of hard harvesting of mature plants especially in Nusa Tenggara Barat and Nusa Tenggara Timur Provinces (Herber, 2003; Rindyastuti et al., 2019). The limited area are caused by land cover conversion and the opening of land forest to be traditional farming that has been burning the land frequently in Flores (Figa & Oktavia, 2020).

This population is decreasing in the wild so that the Indonesian government has a policy to take the trading quota of *G. versteegii* in Appendix II CITES (Convention on International Trade in Endangered Species) (Dwianto et al., 2019; Rindyastuti et al., 2019). This species in nature itself is one of the threatened plant species (Susilo et al., 2014). Unlike *Aquilaria* species, *G. versteegii* has not yet been included in the IUCN Red-list. According to IUCN this species is Not Evaluated and Data Deficient (IUCN, 2020).

IUCN has provided relevant criteria for all species in the world to evaluate the conservation status of a species. The purpose of this categorization is to give the world public awareness of the importance of conservation and to help policy makers to improve the conservation status of species that are already on the IUCN red list (Widodo et al., 2011). GeoCAT (Geospatial Conservation Assessment Tool) is a web based application that can be used to determine the conservation status. Not many agarwood species has been assessed with this application, in this case, *Gyrinops versteegii*. It is hoped that with the results of the assessment of the conservation status of *G. versteegii* species, the public will be more aware of the importance of conservation of this agarwood-producing plant. In fact, not just agarwood production, this agarwood plant also has been used as other utilization including handicrafts, therefore ethnobotanical notes on this species is also a good addition to the *G. versteegii* data. This paper aimed to assess the scarcity status of *Gyrinops versteegii* agarwood-producing species based on distribution data records from both herbarium and field results to assist in the formulation of its conservation strategy.

METHODS

Data source and tools

Past occurrences record of *G. versteegii* was obtained from the Global Biodiversity Information Facility or GBIF (GBIF Secretariat, 2021 <https://www.gbif.org/species/3568490>). These

information was used to choose the *Gyrinops versteegii* data (distribution, population, and macroclimate) (García-Roselló et al., 2015). There have been found 25 occurrences records, but there are only 3 records with geo-references, i.e. one on Lombok Island and two in Papua Province. From direct searches at the *Hortus Botanicus Baliense* in the Bali Botanic Garden, we examined the HK.762 specimen dated July 3, 2006 with the sampling location in West Lombok but the coordinates are missing. From an online search at the National Herbarium Nederland Universitet Leiden, herbarium specimen *G. versteegii* number L.0830233 mentions that this species was found in forests in West Sumbawa (missing coordinates) in 1993.

Field study

Field exploration was conducted on 2018 and 2019 in NTB and NTT (Figure 1) to find out the latest distribution of both cultivated and natural *G. versteegii*. Handheld Garmin GPS was used to record the geographic coordinates of *G. versteegii*. Specimens (evidence of exploration) were stored in the *Herbarium Hortus Botanicus Baliensis*, “Eka Karya” Bali Botanical Garden in Bedugul. An ethnobotanical note of *G. versteegii* from the field was obtained by conducting open interview to key informant.



Figure 1. Field study locations to record *Gyrinops versteegii* data.

Data base analysis

Geographical and ecological data resulting from field exploration are invaluable sources of information for EOO, AOO, and fragmentation. AOO (Area of Occupancy) is the area occupied by taxons in the more common Extent of Occurrence (EOO) (IUCN 2012), and is usually used as a measure of species distribution. AOO species is one of the more commonly used parameters in IUCN Red List assessments. Specific measurements of the

geographic range of species (EOO) and AOO are used in assessing the IUCN Red List based on Criterion B. The area of Occupancy (AOO) used in the analysis is based on the rules of the IUCN with a grid cell width of 2 km (IUCN, 2012).

GeoCAT (Geospatial Conservation Assessment Tool) was used to determine AOO and EOO. The GeoCAT is a web-based application tool that uses primary biological data for semi-automatic IUCN Red List assessment and analysis (Bachman & Moat, 2012). This web-based tool is an open source for fast geospatial analysis to facilitate the self-assessment of Red List species (Bachman et al., 2011). The web address is available at <https://www.kew.org/science/our-science/projects/geocat-geospatial-conservation-assessment-tool>. All coordinate points from the encounter with *G. versteegii* in the field during exploration were entered into GeoCAT. Likewise, the coordinate points obtained from the herbarium search results and the GBIF. Then, to get an overview of EOO and AOO, the enable EOO / AOO button was selected in the application. The application was

automatically draw the polygon and calculate the area of EOO and AOO along with the recommended conservation status. The analysis results were saved (in GEOCAT file format) to be processed further.

RESULTS AND DISCUSSION

Taxonomy note

The descriptions of the living and herbarium collections (Figure 2) from *Gyrinops versteegii* at the Bali Botanic Garden show the following descriptions: The stems are brown, sometimes some are white; tree height can reach 12 m; the leaf size is about 4 cm wide by about 13 cm long; single leaf; incomplete leaves; alternate leaves; the edges of the leaves are flat; elongated leaf shape; the tip of the leaf is tapered; dark green leaf color; glossy smooth leaf surface; flowers in tubular or funnel-shaped with 5-6 crowns; axillary flower; panicles; androgynous flower. The fruit is oval and fleshy (Figure 2). The color of the young fruit is green, after being old it becomes reddish yellow, and will break off by itself.



Figure 2. Herbarium *Gyrinops versteegii* in the *Hortus Botanicus Baliensis* (Left); *Gyrinops versteegii* fruit and seeds from exploration on Lombok Island, NTB 2018 (right)

Habitat Ecology

Habitat data together with distribution data are two very important things in the effort to conserve *Gyrinops versteegii* species. *Gyrinops* spp. distribution data collection obtained from the field survey (Figure 3) were recorded for their position using GPS (Table1). Microclimate as well as topographic data of *Gyrinops versteegii* habitat were also recorded. From the results of these field exploration activities, we found the distribution of *G. versteegii* which is mostly cultivated by the

community (only a few *G. versteegii* were found in natural forests). From the results of our field observations on the island of Lombok, it was known that in general the *G. versteegii* observation plots were located at an altitude of 100 - 900 m asl, the slope of the soil ranged from 0-18°, with a soil pH of 6 - 6.5, they had an air temperature ranging from 26 - 31° C, relative humidity around 70 - 80% with a sunlight intensity of 300 - 10000 lux. The results of the ordination analysis also showed that *G. versteegii* was thought to have a correlation with soil pH, soil

moisture, sunlight intensity, and air temperature (Roemantyo & Partomihardjo, 2010; Sitepu et al., 2011; Sutomo & Oktavia, 2019). Refer to Yulistyarini et al. (2020), the distribution of *G. versteegii* has a strong correlation between the content of C organic and Soil Organic Matter (SOM) in Manggarai - Flores. This condition makes an indication that the preference location of *G. versteegii* is the fertile soil naturally.



Figure 3. Field exploration activities to determine the distribution and population of *Gyrinops versteegii* in NTB and NTT. Making a plot at the location in which *G. versteegii* was found.

Table 1. Location and recording coordinates of the exploration results of *Gyrinops versteegii* in NTB and NTT

Longitude (°)	Latitude (°)	Altitude (m asl)	Location
120.67973111100	-8.76364000000	432	East Manggarai, Flores Island
120.69359388900	-8.74995305556	601	East Manggarai, Flores Island
120.69359388900	-8.74995305556	741	East Manggarai, Flores Island
120.69359388900	-8.74995305556	741	East Manggarai, Flores Island
120.70899305600	-8.76177111111	841	East Manggarai, Flores Island
120.70894305600	-8.76182500000	841	East Manggarai, Flores Island
121.19223194400	-8.85339194444	499	Nagekeo Flores
121.19197305600	-8.85337194444	499	Nagekeo Flores
121.19192388900	-8.85325611111	499	Nagekeo Flores
121.19187611100	-8.85301194444	499	Nagekeo Flores
122.73164694400	-8.51773500000	306	East Flores, Flores Island
122.73216388900	-8.51837500000	306	East Flores, Flores Island
122.73291805600	-8.52022611111	315	East Flores, Flores Island
122.73951500000	-8.52498000000	392	East Flores, Flores Island
122.74068111100	-8.52541111111	410	East Flores, Flores Island
122.43284694400	-8.68820111111	878	Sikka, Flores Island
122.43497305600	-8.69097111111	862	Sikka, Flores Island
122.44237805600	-8.69610694444	725	Sikka, Flores Island
122.44237611100	-8.69666888889	708	Sikka, Flores Island
122.44127500000	-8.69811500000	678	Sikka, Flores Island
122.43659805600	-8.69846500000	659	Sikka, Flores Island
121.81395000000	-8.69595000000	1104	Ende, Flores Island
116.55880845200	-8.51046002470	922	East Lombok, Lombok Island
116.46584250000	-8.49849125370	925	East Lombok, Lombok Island
116.54835311700	-8.51557902060	466	East Lombok, Lombok Island
116.55032663600	-8.52253591642	440	East Lombok, Lombok Island
116.07757908300	-8.46609746106	423	North Lombok, Lombok Island
116.07741924000	-8.46622017212	427	West West Lombok, Lombok Island
116.08879214200	-8.46562857740	384	West Lombok, Lombok Island
116.08804305100	-8.46628236584	342	West Lombok, Lombok Island
116.08614714800	-8.46763210371	393	North Lombok, Lombok Island
116.07910140400	-8.46637263894	422	North Lombok, Lombok Island
116.07761965100	-8.46609410830	388	North Lombok, Lombok Island
116.08039096000	-8.46633274108	405	Central Lombok, Lombok Island
116.29279702000	-8.55700255372	435	Central Lombok, Lombok Island
119.00788600000	-8.53572800000	50	Bima, Sumbawa

119.11138200000	-8.67909500000	793	Bima, Sumbawa
118.84692600000	-8.52445400000	388	Bima, Sumbawa
118.83834500000	-8.64498900000	626	Bima, Sumbawa
117.80975400000	-8.18689500000	474	Dompu, Sumbawa

Ethnobotanical note

Various uses of agarwood still revolves around its use as seeds, wood to be sold or distilled, and medicine that haven't been too well socialized by society (Mulyaningsih et al., 2017). Naturally, agarwood sold in the market has various grade and price. The level of quality/grade of agarwood so far can be tested with image analysis using the spectral grayscale on its images (Qomariyah et al., 2019). One of the agarwood farmers in East Manggarai stated that he did not want to use the agarwood injection method in an effort to produce agarwood, but only used mechanical methods with only injuries. One of the reasons why they did not choose to use the injection method was because they did not want the *G. versteegii* tree to be exposed to chemicals because these farmers also used the bark and the leaves as raw materials for making traditional liniment. One of the ingredients of the liniment are the bark and the leaves

of agarwood plant plus a mixture of other spices (19 types of spices). The agarwood farmer has also attended training from the Indonesian Food and Drug Research Institute (BPOM), and now his traditional medicine is in the process of making a permit. One pack of liniment is sold for around 30 to 50 thousand rupiah. In addition to liniment, the farmer also makes handicrafts from *G. versteegii* wood in the form of a set of glasses and others (Figure 4) which are used to serve guests typical Flores drinks (moke/ sopi). From this explanation, it can be concluded that agarwood plays an important role in the source of livelihood for some residents of the Flores community. The utilization of *Gyrinops versteegii* in Sumbawa tends to have fewer uses apart from its wood for sale. In Sumbawa, it is known to be used as traditional medicine however this information is lacking in the literature (Sukenti & Mulyaningsih, 2019).



Figure 4. Handicrafts in the form of drinking *sopi/moke* tools made of *Gyrinops versteegii* wood on the island of Flores

Current population trend

From the results of our field search on three islands, namely Lombok, Sumbawa and Flores, it is known that most of the existing agarwood are cultivated by the community. The highest number of agarwood was found on the island of Flores, followed by Sumbawa and Lombok (Figure5).

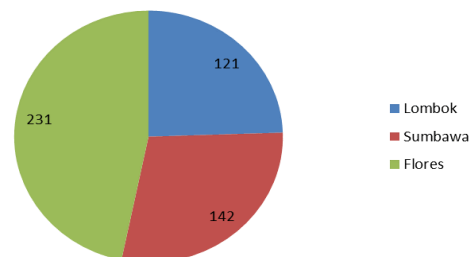


Figure 5. Proportion of the number of cultivated *Gyrinops versteegii* individuals found at the exploration site

In Lombok, people are familiar with agarwood from the *G. versteegii* species. Based on the stories of the elders, it was known that many Lombok people in the past were looking for natural agarwood in the forest. But now the existence of agarwood that grows naturally in the forest is very difficult to find. From the results of our search on the island, natural agarwood can only be found in Mount Rinjani Resort Aikmel National Park and even then only two individuals. The natural agarwood population is decreasing from year to year. To overcome the scarcity of *G. versteegii* along with forest destruction on the island of Lombok, the Government has implemented a reforestation program through the Forestry Service and other relevant agencies. The *G. versteegii* planting program was carried out in 1999-2006 at BKPH Rinjani Barat (personal communication, 2018) by the Forest Service; 1997-2001 in the Senaru Educational Forest by the University of Mataram and BPDAS Dodokan Mulyosari; 1997-2006 at KHDTK Rarung Research Forest by the Ministry of Forestry. The previous study also stated that the planting status of *G. versteegii* found in the research location is dominated by production plants owned by residents (Sutomo & Oktavia, 2019).

According to the story of local community member in Manggarai, Flores Island, since 1978, the trend of the community is looking for agarwood in the forest. Natural agarwood that grows naturally in the forest is extracted by means of cutting. This possibility is one of the causes of the increasing scarcity of natural agarwood trees in forests in Flores in general today. For the record, agarwood that grows in natural forest is *Gyrinops versteegii*, with the local name *Sukka*. There is one *G. versteegii* tree which is thought to have grown naturally (possibly due to being spread by birds or otherwise) growing on the slopes of the Bukit Sandang cliff forest in East Manggarai Regency, Flores Island. Other agarwood we encountered in Flores were the result of planting

by the community as a cultivated plant (Iryadi et al., 2021). *Gyrinops versteegii* could be classified into slow-growing species because the diameter increment is 0.5 cm/year and the cultivated *G. versteegii* was grown faster than the natural one (Dwianto et al., 2019).

On the island of Sumbawa, apart from the agarwood that is on the land owned by the residents, we also found agarwood that grows wild/naturally in natural forests of Alas Saboke in Lambu Village, Lambu District, Bima Regency. At this location, we found nine natural agarwood trees with an average diameter of 8 cm with an average height of about 7 m. There were six seedlings at the site and no *G. versteegii* fruit was found. From the records of other researchers, it is also known that in Sumbawa, natural *G. versteegii* has been found at an altitude of 400-800 m asl from Mount Doro Tambiung in West Sumbawa to Mount Doro Saboke in East Sumbawa (Mulyaningih & Yamada, 2007).

Conservation status assessment

From the analysis using GeoCAT, it was found that the estimated Extent Of Occurrence (EOO) was 868,422,919 km², exceeding the value required for the threatened category. According to the EOO, *Gyrinops versteegii* is included in the Least Concern (LC) category; however, the distribution was not continuous within the imaginary boundary, which can be drawn to include all occurrences of this species. In addition, the EOO as shown in the Figure 6 covers a large area of the ocean. Area Of Occupancy (AOO) of this species was 116 km². It meets criterion B, (estimated AOO of less than 500 km²) (IUCN, 2012). It is therefore considered to be at very high risk of extinction in the wild (EN). In other words, we can say that the value of AOO is considered more reliable. Therefore the category of the calculation of AOO can be used as a parameter to decide the conservation status of *G. versteegii*.

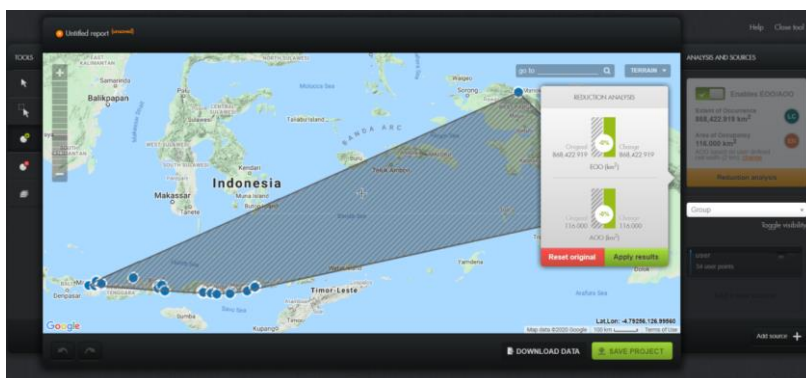


Figure 6. Results of data analysis using the Geospatial Conservation Assessment Tool / GeoCAT <http://geocat.keew.org/>

The number of locations and the continued decline of natural agarwood (*G. versteegii*) is not certain because of the three natural sub-populations we found from our fieldwork, two were inside the protected areas (Lombok and Sumbawa) and one was outside the protected areas (Flores). However, natural *G. versteegii* may or may not occur outside of these three areas where threats are more intense and natural habitat decline continues. From sampling the natural agarwood population in the field, we estimate that the population is small and is thought to be included in the endangered category under criterion C with a total number of less than 2,500 individuals and possibly less than 250 adults in each subpopulation. It can be concluded that the conservation status of *Gyrinops versteegii* can be categorized into endangered (EN) EN - Endangered, C2a (i) (IUCN version 3.1). GeoCAT is a very useful tool in aiding to assess conservation status of a targeted species. The GeoCAT has also been used in various assessment of different species such as the tree fern *Cibotium* which is included in the threatened category in Indonesia (Praptosuwiryo, 2020).

Conservation efforts

According to Roemantyo & Partomihardjo (2010), field data and herbarium collections of agarwood-producing plant species collected after the 1970s were very limited. Only 7 species of data were recorded (including *G. versteegii*) by Partomihardjo & Roemantyo from Herbarium Bogoriense, namely *A. malaccensis*, *A. microcarpa*, *A. beccariana*, *A. hirta*, *A. cumingiana*, *A. filaria*, *G. versteegii*, and *G. ledermannii*. This phenomenon can indicate whether the population of this species of agarwood is decreasing in its natural habitat in addition, data collection and research on the existence of natural gaharu species is also limited.. Even now, it is very likely that the population of agarwood producing species in their natural habitat is decreasing. This is because it is estimated that many natural habitats of these plants have changed their function from natural forests to other non-forest uses, such as settlements, transmigration, plantations/ agriculture, industrial areas, and so on (Roemantyo & Partomihardjo, 2010).

In efforts to conserve *G. versteegii* species, it is necessary to analyze regional recommendations for cultivation as we have done for Flores Island (Sutomo & Iryadi, 2018). The determination of this recommendation area is attempted as part of the planning in the cultivation of *Gyrinops versteegii* so that the planting can grow optimally and the results will be the same. In addition, conservation efforts of *Gyrinops versteegii* can also be carried out to prevent illegal logging of this plant in nature (Iryadi et al., 2021). For cultivation locations, we also pay attention

to the status of the area, whether forested or not, in this case, a non-forest area is chosen. The process of preparing the directions for the cultivation area refers to field data regarding the conditions where these plants were found. For the character of land units we used the landform approach, as well as the classification of the elevation of areas and non-forest areas. By using a matching analysis with a binary approach, we overlaid three parameters, namely, land shape, elevation zoning, and class of non-forest areas (Sutomo & Iryadi, 2018).

In addition, *ex situ* conservation efforts in the form of germplasm collection in a botanical garden are also needed. Apart from the five botanical gardens managed by the Indonesian Institute of Sciences (LIPI), the development of regional botanical gardens is currently being developed. In NTB, currently there is Lemor Botanical Garden in East Lombok. Meanwhile, in NTT, efforts are being made to build the Wolobobo Botanical Garden in Ngada, Flores Island.

Aquilaria filaria and *Aquilaria malaccensis* have been widely known by the public and have been widely cultivated. In the IUCN Red list, *Aquilaria malaccensis* is included in the critically endangered (CR) category (Harvey-Brown, 2018). On the other hand, although *Gyrinops versteegii* is starting to be sought after as a type of agarwood producer other than *Aquilaria*, it has not been much cultivated and along with the decreasing natural *G. versteegii* in its habitat, causing concern about the future of this species. As one of the native plants from East Indonesia area (GBIF, 2017), agarwood from wild is very wanted on the global market. Until now, detailed data on the status of its existence and conservation are limiting information (Sutomo & Iryadi, 2019). Data population and conservation status are very important for input to provide information on the quota wild-harvesting of agarwood. This has used to be recommendation the conservation status of the species *G. vertegii*. Recommendations for the conservation status of *G. versteegii* are expected to provide input to stakeholders in the quota for taking this species in the wild and as an effort to cultivate this species by the surrounding community to prevent the threat of natural agarwood. It is hoped that with the results of the assessment of the conservation status of *G. versteegii* species, the public will be more aware of the importance of conservation of this agarwood-producing plant.

CONCLUSION

Gyrinops versteegii can be recommended into EN (endangered) status in nature. This information is

used as a recommendation in the quota of its wild-harvesting status and there will be regulations for cultivated *Gyrinops versteegii* agarwood in terms of cultivation, processing, and marketing.

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