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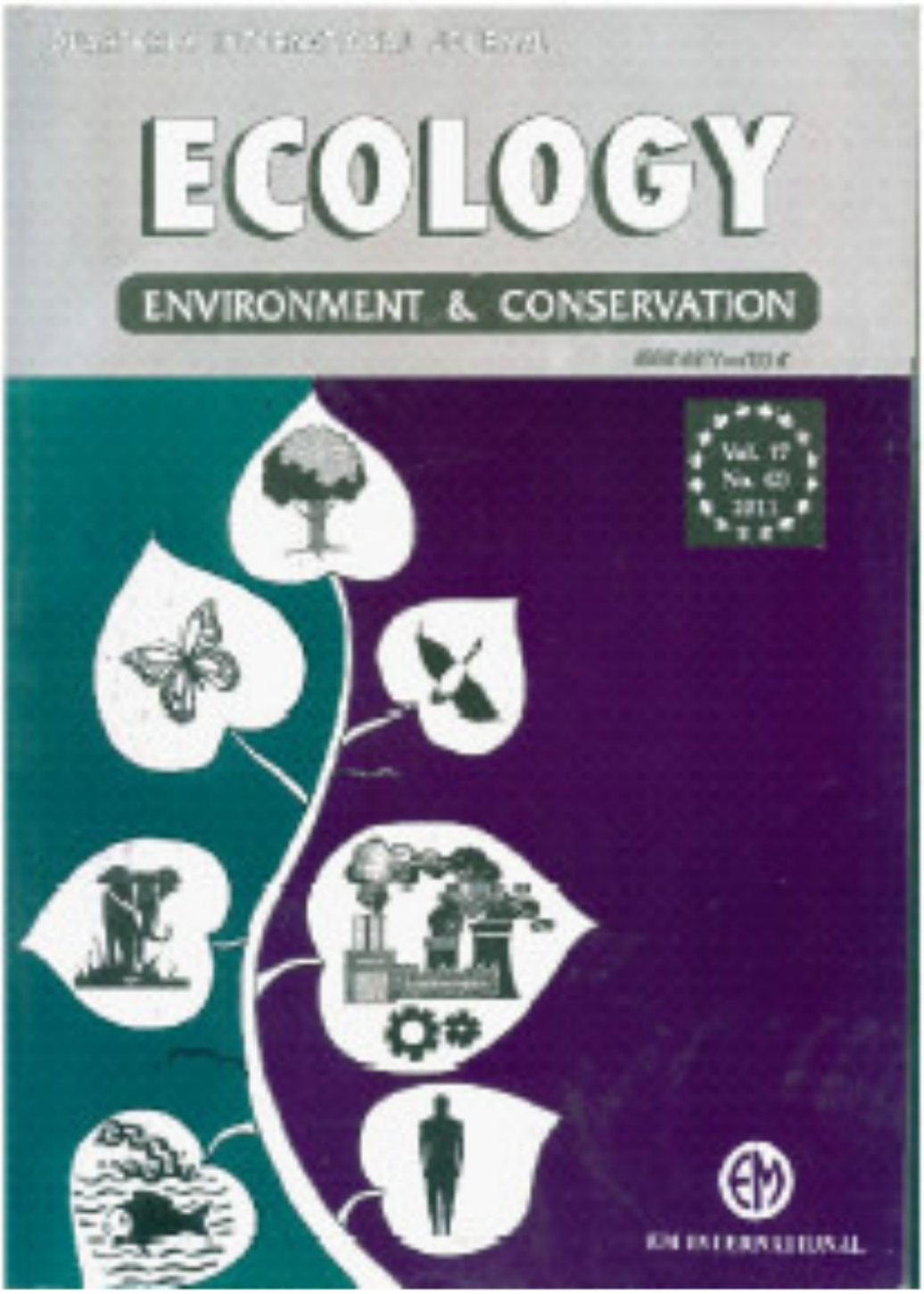
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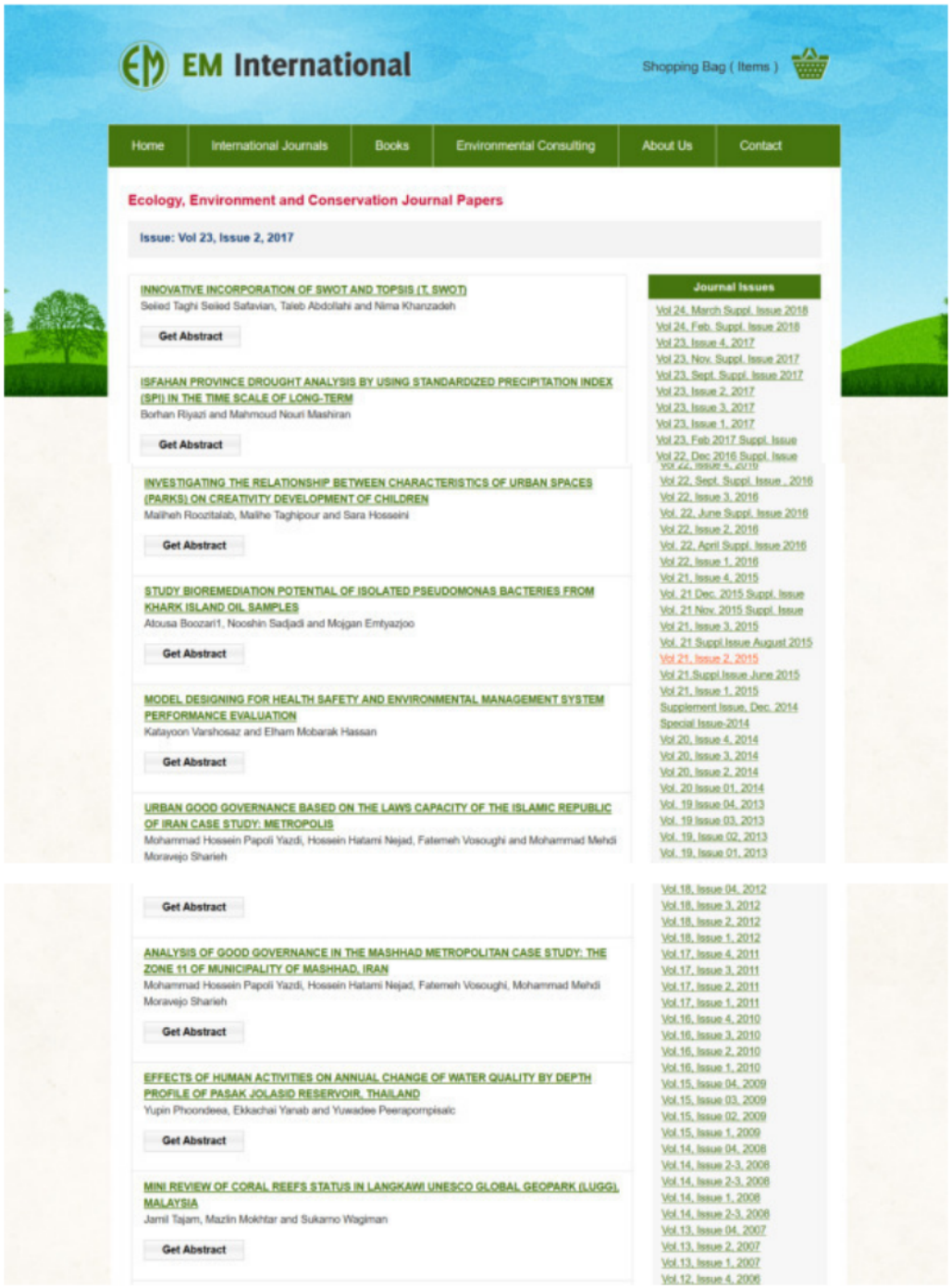

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The presense of eaglewood *Gyrinops versteegii* in the natural forest of West Lombok Island, Indonesia

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ABSTRACT

This research aims to determine the existence of eaglewood trees in natural forests of west Lombok island, Indonesia. Sampling areas in this study is geographically located at coordinates: 8°15 '- 8°40' South Latitude and 116°00 '- 116°20' East Longitude in the western part of Lombok Island. The width of the forest area shown in the satellite image in the West Lombok area is 46357.86 hectares, including primary and secondary forest area with altitude of 0 m - d"1000 m above sea level. This area was delineated to become a map of *G. versteegii* distribution consisting of 64 releves. The result shows that the existence of eaglewood in the natural forest located in western part of Lombok is very rare. Eaglewood that can be found in the natural forest is only at seedling and sapling stages. Meanwhile, the existence of eaglewood at pole stage is very rare, and even eaglewood at tree level can no longer be found. Eaglewood that is at pole and tree stage can be found in owned agroforestry, coffee and cocoa plantation.

Key words : *Gaharu, Eaglewood, Gyrinops versteegii, Lombok.*

Introduction

Genera *Aquilaria* and *Gyrinops* belonging to the subfamily of Aquilarioideae (Domke, 1934) and the family of Thymelaeaceae are eaglewood producing high quality agar. There are eleven species of Genus *Aquilaria* producing aromatic resin: *A. sinensis*, *A. khasiana*, *A. crassna*, *A. rostrata*, *A. malaccensis* (*A. agallocha*), *A. beccariana*, *A. filaria*, *A. hirta*, *A. microcarpa*, *A. cumingiana* and *A. subintegra*. There are seven species of genus *Gyrinops* Gaertner producing agarwood. Five of these species, namely : *G. versteegii, G. ledermannii, G. caudate, G. podocarpus* and *G. salicifolia* can be found in New Guinea. Meanwhile, the other two species: *G. decipiens* is scattered in Sulawesi and G. walla is in Sri Lanka (Ding Hou 1960 and 1964; Ng *et al.*, 1997; Mulyaningsih and Yamada, 2008; and Eurlings and Gravendeel, 2005).

The dispersion of *G. versteegii* is from the eastern islands of Wallace line to New Guinea (Gunn *et al.*, 2004; Ding Hou, 1960). The difference on growing location of *G. versteegii* as in Manokwari and Kebar make the genetic gap become wide on both populations. Therefore, the existence of geographic race will give genetic diversity on the species (Siburian, 2009).

The exploitation of natural agarwood continuously happens in Indonesia tropical forest. Thus, Indonesia was famous as the biggest exporter of agarwood from 1997 to 2001. It is recorded that Indonesia exported 300 ton agarwood per year. However, the export decreased into 150 ton/ year since 2001 – 2003, and from 2004 to present the export

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drastically decreases reaching the point less than half compared to the previous years. This condition made eaglewood species from Genera *Aquilaria* and *Gyrinops* (Thymelaeaceae) were listed in appendix II by the *Convention International Trade in Endangered Species of Wild Flora and Fauna* in Bangkok (Anonymous, 2005) and registered as protected species – red marked- in *International Union for Conservation of Nature and Natural Resources* (Anonymous, 2006).

Agarwood is generally harvested by cutting down trees. It is estimated that 31 – 90 % of eaglewood was cut down between 1999 - 2000. The quality of agarwood produced from each logging was very low with its average weight of 0.10 – 0.18 kg/ tree to 0.19 – 2.13 kg/ tree from low class to super class. In the early 1990s, the trading of agarwood for mixed class originating from logged *Aquilaria* spp. tree could reach 300.000 to 100.000 per year depending on the luck of the agarwood hunters (Soehartono dan Newton, 2001).

The continuous harvest of agarwood by cutting down eaglewood in the forest should not decrease the number of its population. Losing one kind of genus *Gyrinops* Gaertner or one of populations from *Gyrinops* spp. species must not happen before having sufficient information pertaining them. As what happened in India in which the population of *Aquilaria* spp. is extinct particularly in Pradesh, Assam and Meghalay (Chakrabarty, *et al.*, 1994). This condition also applies in Brunei Darussalam (Yamada, 1995).

Eaglewood of *G. versteegii* is commonly known as "Ketimunan tree" (vernacular name) in Lombok. This species spreads from Lombok Island to eastwards along the Lesser Sunda Islands, Maluku Islands to Papua (Mulyaningsih & Yamada, 2008; Ding Hou, 1964). In 1970s, Ampenan, Lombok is one of regions exporting agarwood to Middle East countries, particularly Saudi Arabia in which agarwood Ampenan was quite popular. According to entrepreneurs and agarwood hunters in Lombok, agarwood in West Nusa Tenggara (NTB) is from West Lombok, Central Lombok, Sumbawa, Dompu, and Bima. However, starting from 1990s. Ampenan was no longer agarwood exporter of agarwood coming from forests in NTB area. This research aims to determine the existence of agarwood trees in natural forests of west Lombok island, Indonesia.

Materials and Methods

Geographically, the study area is located at coordinates: 8°15'- 8°40' South Latitude and 116°00'- 116°20' East Longitude. The width of the forest area shown in the satellite image in the West Lombok area is 46357.86 hectares, including primary and secondary forest area with altitude of 0 m - d"1000 m above sea level. This area was delineated to become a map of *G. versteegii* distribution consisting of 64 releves.

The sampling method was used four variation sampling unit (SU) depend to four growth level. Measurement of the sampling unit for each level of growth is as follows: seedlings: SU size 2m x 2m; saplings: SU size 5m x 5 m; poles: SU size 10m x 10m; tree: SU size 20 x 20 m. There two types of variable in this study: dependent variable covering number of species; and independent variables, consisting of: soil, climate, plant species associated/adjacent to the eaglewood.

There are four kinds of vegetation data collected which are based on four variance of level growth with their criteria as follows: Seedling: 0-150 cm tall of stems; Saplings: diameter is <10 cm and tall of stems is >150 cm; Pole: trunk diameter between e"10 cm - 20 cm Diameter Breast Height (dbh); Tree, is a plant with over 20 cm dbh.

The pattern of vegetation communities were analyzed using ordination methods according to Mueller-Dombois and Ellenberg (1974). To calculate community patterns, determining similarity index of species vegetation from 2 types of releve compared by using the formula Sorensen (Mueller-Dombois and Ellenberg, 1974). Community patterns that indicate the type of inequality is expressed by the dissimilarity index (DI). The value of dissimilarity index (DI) and similarity index (SI) was obtained by comparing matrix-releve between DI and SI.

The value of each releve on the x-axis and y is obtained, these values are projected on 2-dimensional ordination graphics. To determine the validity of the ordination, the correlation test between the index of dissimilarity with the actual distance of the releves or ordination interval (OI) was done. The testing procedure was done by making a comparison of randomly selected releve pair dissimilarity index which is based on the equation proposed by Mueller-Dombois and Ellenberg (1974). Furthermore, the OI value was correlated with randomized-releve pairs DI. According to Moroney (Mueller-Dombois and Ellenberg, 1974), the significance of correlation value could be tested by using *t-test* (Student's t test)

Results and Discussion

Based on ordination analysis on ecosystem clustering of *G. versteegii* and other ecosystems on study site, there are three kinds of ecosystem which are: 1) *G. versteegii* ecosystem; 2) Semi-dry area ecosystem - area with less dense vegetation coverage, moderate humidity, moderate temperature and moderate sunlight intensity; 3) Dry area ecosystem - area with quite open vegetation coverage, low humidity, relatively high temperature and high sunlight intensity.

There are three ecology unit groups on all growth level in the forest located in western part of Lombok (Figure 1-2), which are a) Group I: Unit of eaglewood ecosystem ecology consisting of: (1) Ecosystem ecology unit of *G. versteegii* Beringin group: R3, R8, R16, R29, R43, R45, R46, R47, R48, R50, R52, R56 and R57; (2) Ecosystem ecology unit of *G. versteegii* Buaya group: R13, R23, R27, R29, R38, R40 and R51; (3) Ecosystem ecology unit of *G. versteegii* Madu group: R1, R2, R28, R31, R51, R54, R62, R63 and R64; (4) Ecosystem ecology unit of *G. versteegisi* Pantai group: R20, R34, R35, R41; (5) Ecosystem ecology unit of *G. versteegii* Soyun group: R31; b) Group II: Unit of semi-dry area ecology consisting of: R10, R12, R17, R22, R24, R39, R49, R53, R55 and R60; c) Group III: Unit of dry area ecology consisting of: R4, R5, R6, R7, R9, R11, R14, R15, R18, R19, R21, R25, R26, R30, R32, R33, R36, R37, R42, R44, R58, R59 and R61.

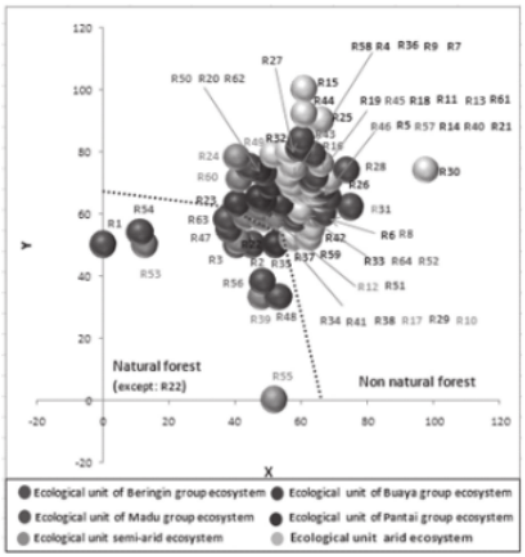

Fig. 1. Ordinate value y / x of 64 releves based G. *versteegii* infraspesific standing position at various stages of growth.

Figure 1 and Figure 2 show that unit of eaglewood ecosystem ecology is situated over lapping with semi-dry area ecosystem ecology unit and dry area ecosystem ecology unit. This shows that the dispersion of eaglewood ecosystem is very wide covering humid, moderate and to relatively dry area depending on its population. The eaglewood found in natural forest can be seen in Figure 1 and Figure 2, which are: a) eaglewood Madu group found in releve R1, R2, R54 and R63; b) eaglewood Beringin group found in releve R3, R47, R48 and R56; c) eaglewood Pantai group found in R35, meanwhile

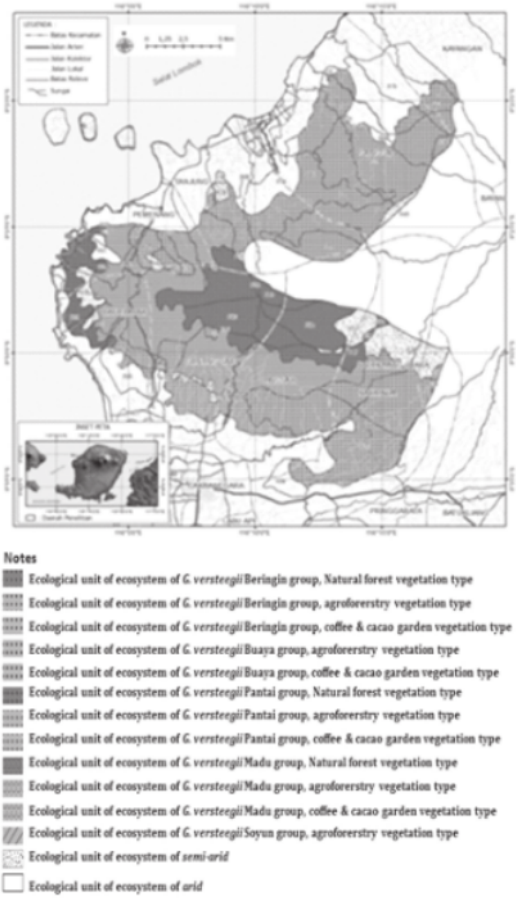

Fig. 2. Vegetation map ecological units of *G. versteegii* ecosystem at various stages of growth in the forest located in western part of Lombok.

for eaglewood Pantai group and eaglewood Soyun Group cannot be found in natural forest area.

Eaglewood Madu group and eaglewood Beringin group have the ability to live in humid area (area with dense vegetation coverage) to quite dry area (area with quite open vegetation). Eaglewood Beringin group can be found in the forest area that has converted into agroforestry area, which are in: R8, R16, R29 and also in forest area that has converted into coffee and cocoa plantation, which are in: R43, R45, R46, R50, R52 and R5.

Eaglewood Madu group is found in R28, R31, R41, R62, R64 of agroforestry area and only one releve, R51, is found in coffee and cocoa plantation. Eaglewood Pantai group can be found in semi-dry areas except natural forest area which are in releve R20, R41 of agroforestry area and in R34 of coffee and cocoa plantation. Meanwhile eaglewood Buaya group is found in semi-dry areas which are R23 (agroforestry area), R38, R29 (coffee and cocoa plantation), and in dry areas (quite open area) which are R23 (agroforestry area), R23, R27, R40 (coffee and cocoa plantation). However, eaglewood Soyun group is only found in R31 which is a quite dry area in agroforestry area (Figure 1 and Figure 2).

The existence of eaglewood in the forest located in western part of Lombok area shows a significant decrease. The scarcity of eaglewood on each group can be seen from Importance Value Index (IVI) result, respectively: *G. versteegii* Beringin group IVI= 7.58, *G. versteegii* Madu group IVI= 4.25, *G. versteegii* Buaya group IVI= 3.37, *G. versteegii* Pantai group IVI= 3.15 and even on *G. versteegii* Soyun group IVI merely 0.27.

The units of eaglewood ecosystem ecology at the seedling stage

The ordination analysis that is based on dissimilarity index value shows that the existence of eaglewood at seedling stage can only be found in the area that is supervised by the land owner as in releve: R28, R31, R62 and R64 for eaglewood Madu group (*G. versteegii* Madu group), releve: R8, R29, R46 dan R57 for eaglewood Beringin group (*G. versteegii* Beringin group); and that is far from the reach of eaglewood seedling collectors such as:

R8, R29, R46 dan R57 for eaglewood Beringin group (*G. versteegii* Beringin group); and that is far from the reach of eaglewood seedling collectors such as in R3, R47 and R48 (*G. versteegii* Beringin group) and R54 (*G. versteegii* Madu group).

Related to the existence of eaglewood in non-natural forest area – agroforestry and plantation, some groups can be found. Groups that can be found in agroforestry area are: Beringin group in R8 and R29, Madu group in R28, R31, R62, and R64. Beringin group can also be found in mixed coffee and cocoa plantation on releve R46 and R57. Meanwhile, Madu group cannot be found in this area.

It is documented that there are 69 species at the seedling stage. Furthermore, based on the IVI, the dominant plants at canopy layer are *G. versteegii*, *Mangifera* sp., *Arenga pinnata*, *Pterospermum javanicum*, *Syzygium polyanthum*, *Diospyros javanica*, *Dracontomelon costatum*, *Calophyllum inophyllum*, *Chisocheton pentandrus*, *Sandoricum koetjape* and *L. domesticum* Langsat group. The eaglewood that are on seedling stage have quite high IVI. There are only two populations of eaglewood found which are *G. versteegii* Beringin group with IVI= 15.3 and *G. versteegii* Madu group with IVI=8.48. Meanwhile Buaya Group, Pantai group and Soyun group are not found, therefore the IVI is zero. This shows that the area of the eaglewood of that group particularly those which are at seedling stage was intensively exploited by the eaglewood seedling collectors.

The units of eaglewood ecosystem ecology at the sapling stage

The ordination analysis that is based on DI value shows that there are four eaglewood groups which are eaglewood Beringin group, eaglewood Buaya group, eaglewood Madu group, and eaglewood Pantai group at the sapling stage. Among these groups, three groups can still be found in the natu-

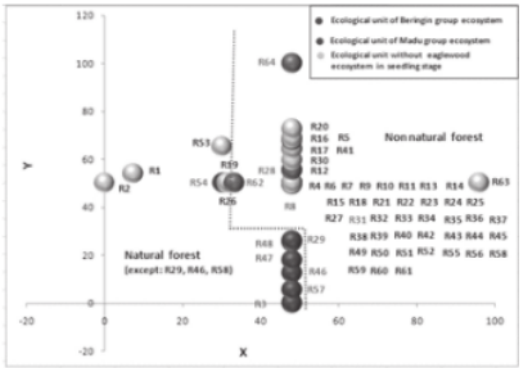

Fig. 3. Ordinate y / x value of 64 releves based G. *versteegii* infraspesific standing position at the seedling stages

ral forest area: eaglewood Beringin group in releve R47 and R48; eaglewood Madu group in releve R1, R2, and R54, eaglewood Pantai group in releve R35. Some eaglewood can be found in the non-natural forest area: agroforestry area - such as eaglewood Beringin group in releve R8, eaglewood Buaya group in releve R23, eaglewood Pantai group in releve R20 and R41, and eaglewood Madu group in releve R28, R31, R41, R62 and R64.

It is documented that there are 83 species at the sapling stage. Based on the IVI, the dominant plants at canopy layer are: *Theobrona cacao*, *Bambus*a sp. *G. versteegii*, *Baccaurea racemosa*, *L. domesticum* Langsat group, *Swietnia macrophylla*, *Calophyllum inophyllum*, *Calophyllum soulattri* , *Mangifera* sp. and *Chisocheton pentandrus*. The Eaglewood found show a quite high IVI in which the highest is at the third rank: eaglewood Beringin group IVI=15.06, *G. versteegii* Madu group IVI = 14.03 and *G. versteegii* Madu group IVI =11.68, *G. versteegii* Buaya group IVI =

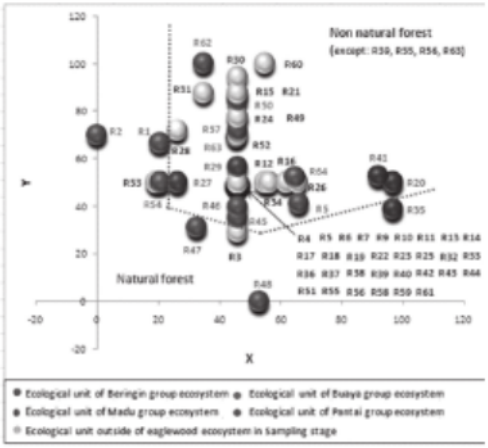

Fig. 4. Ordinate value y/ x of 64 releves based on G. *versteegii* infraspesific standing position at the sapling stages.

5.97 respectively. However, *G. versteegii* Soyun group cannot be found, thus the IVI is zero.

The units of eaglewood ecosystem ecology at the pole stage

The ordination analysis that is based on dissimilarity index value shows that *G. versteegii* Madu group is the only eaglewood at pole stage that can be found in the natural forest area. Meanwhile, related to the existence of eaglewood groups in non-natural area, there are four groups can be found: a) *G. versteegii* Beringin group can be found in releve R8 and R29 of agroforestry area, and in releve R43, R45, R52 and R57 of coffee and cocoa plantation; b) *G. versteegii* Buaya group can be found in releve R40 of agroforestry area, and R23 and R51 of coffee and cocoa plantation; c) *G. versteegii* Pantai group can be found in releve R20 and R40 of agroforestry area, and in coffee and cocoa plantation; d) *G. versteegii* Buaya group can be found in releve R28, R31, R54, R62 and R64 of agroforestry area.

Eaglewood Madu group is found in R28, R31, R41, R62, R64 of agroforestry area and only one releve, R51, is found in coffee and cocoa plantation. Eaglewood Pantai group can be found in semi-dry areas – except natural forest area - which are in releve R20, R41 of agroforestry area and in R34 of coffee and cocoa plantation. Meanwhile eaglewood Buaya group is found in semi-dry areas which are R23 (agroforestry area), R38, R29 (coffee and cocoa plantation), and in dry areas (quite open area) which are R23 (agroforestry area), R23, R27, R40 (coffee and cocoa plantation). However, eaglewood Soyun group is only found in R31 which is a quite dry area in agroforestry area (Figure 1 and Figure 2).

It is documented that there are 83 species at the pole stage. Based on the IVI, the dominant plants at canopy layer are: *Theobrona cacao*, *Gnetum gnemon*, *Areca catechu, Anacardium ocidentale*, *Mangifera indica*, *Baccaurea racemosa*, *Durio zibethinus*, *Artocarpus heterophyllus*, *Swietnia macrophylla*, *Mangifera* sp. The

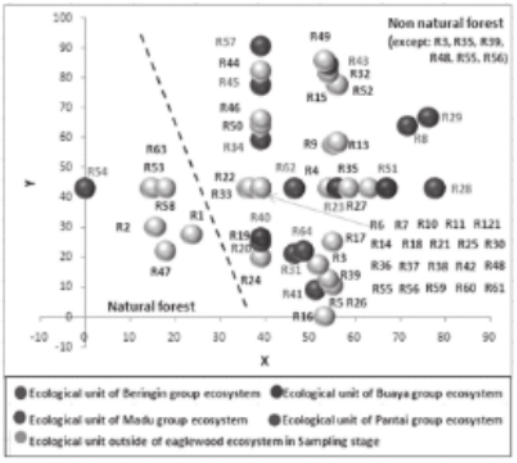

Fig. 5. Ordinate value y/ x of 64 releves based on G. *versteegii* infraspesific standing position at the pole stage.

eaglewood found show a quite low IVI in which the highest is at the eleventh: eaglewood Madu group IVI= 7.28, *G. versteegii* Beringin group IVI = 6.75 and *G. versteegii* Pantai group IVI = 4.34, *G. versteegii* Buaya group IVI = 3.43 respectively. However, *G. versteegii* Soyun group cannot be found at the pole stage, thus the IVI is zero.

The units of eaglewood ecosystem ecology at the tree stage

The ordination analysis that is based on dissimilarity index value at tree stage shows that eaglewood from all groups cannot be found in the natural forest area. This is due to intensive agarwood hunting. The existence of eaglewood at the tree level is only in the area that is being supervised the land owner. There are five groups of eaglewood found in the non-natural forest area: a) *G. versteegii* Beringin group is found in releve R16 and R29 of agroforestry area, and R45 and R57 of the coffee and cocoa plantation; b) *G. versteegii* Buaya group is found in releve R13, R29, and R38 of the agroforestry vegetation type, and in R27 of the coffee and cocoa plantation; c) *G. versteegii* Pantai group is only found in the agroforestry area; d) *G. versteegii* Madu group is found in releve R31, R41, R62, and R64 of the agroforestry area, and in R51 of the coffee and cocoa plantation; e) *G. versteegii* Soyun group, this group is almost extinct because this group can only be found in releve R31 in the study site.

It is documented that there are 83 species at the tree level. Based on the IVI, the dominant plants at

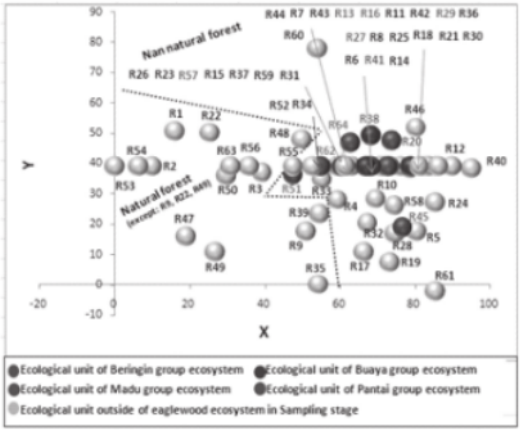

Fig. 6. Ordinate value y/x of 64 releves based on G. *versteegii* infraspesific standing position at the tree stage.

canopy layer are: *C. nucifera*, *M. indica*, *A. pinnata*, *Erythrina orientalis*, *Artocarpus heterophyllus*, *A. ocidentale*, *G. gnemon*, *S. macrophylla*, *S. polyanthum*, *B. racemosa*. The eaglewood shows a very low IVI. The IVI of *G. versteegii* Madu group is only 3.14, then followed by *G. versteegii* Buaya group = 2.58, *G. versteegii* Beringin group = 2.52, and the lowest is *G. versteegii* Pantai group with IVI = 0.51

The condition showed on the ordination analysis pointing that eaglewood at tree stage can no longer be found in the forest area is understandable. This is due to extensive hunting of Eaglewood in The forest located in western part of Lombok area (Figure 2). Information obtained from agarwood entrepreneurs and hunters in Lombok and Sumbawa Indonesia (2005) reveals that before 1980s, agarwood hunting in Lombok and NTB forest was done by picking agar from molded and decayed ketimuan tree on the ground. However, since the availability of molded and decayed ketimunan tree decreased, the hunters began to cut eaglewood. This situation happened intensively between 1980 – 1990. After 1990, eaglewood containing agar was very difficult to find in forest. Therefore, the hunters began to cultivate eaglewood traditionally in the forest. The hunters looked for healthy eaglewood in the forest, and then sliced the trunk. After 3 – 12 months, they harvested by scraping the sliced area which was molded and brown in color. The yield from this cultivation is not as good as natural agar. The quality of the yield is very low, it is just in a form of dhum which is usually used as the main material for making perfume.

Due to the extensive hunting of agarwood, the existence of eaglewood at the pole or tree stage is scarce or even no longer can be found in natural forest. According to agarwood hunters, releve R22 and R39 used to be their hunting location. Another noticeable change is the change of land function from natural forest into coffee and cocoa plantation. These facts are presented in the findings of the research in which it shows that only eaglewood at seedling and sapling stage can be found in natural forests. They are in releve: R1, R2, R3, R35, R46, R47, R48, R54, R56 and R63. The finding also shows that eaglewood at tree stage can still be found – only - in releve R54 of natural forest. This situation is depicted on IVI of each eaglewood stage population in which the highest trend is at the level sapling stage followed by seedling stage.

From the aforementioned facts, it shows that the existence of eaglewood in West Lombok natural for-

est is scarce or even already at the level of endanger species. Moreover, one group, *G. versteegii* Soyun group, is only can be found in releve R31 and the only individual that has been scrapped.

Conclusions

The result shows that the existence of eaglewood in the natural forest located in western part of Lombok is very rare. Eaglewood that can be found in the natural forest is only at seedling and sapling stage. Meanwhile, the existence of eaglewood at pole stage is very rare, and even eaglewood at tree level can no longer be found. Eaglewood that is at pole and tree stage can be found in owned agroforestry, coffee and cocoa plantation.

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