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The Vegetation Analysis of Natural Habitat of Wild Nutmeg *(Myristica Spp)* in Halmahera Forest, North Maluku

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***Abstract*— The vegetation analysis of wild nutmeg (*Myristica spp*) in natural habitats reveals the composition and structure of vegetation populations in an ecosystem unity. This study can be used to consider the conservation and management of germplasm of wild nutmeg in the forests of Halmahera Island, North Maluku. The research objective was to determine the vegetation composition and structure of the wild nutmeg habitats. We used the point method with a plotless sampling technique to record the species at specific points along a transect. The results revealed that naturally *Myristica spp* could grow and develop under large basal areas from the vegetation types, e.g. *Ficus benyamina, Vatica Papuana, Paraserianthes falcataria, Vitex cofassus,* and *Mimusops elengi. Pometia pinnata* and *Duabanga moluccana* can affect environmental factors in the natural habitat of wild nutmeg. *Myristica spp, Euterpe edulis,* and *Macaranga sp* are vegetation types in natural habitats of wild nutmeg with high dominance and important value index (IVI). *Euterpe edulis* can be used as an indicator of the uniqueness of the natural habitat of wild nutmeg. At the same time, *Macaranga sp* indicates that there has been a change in the ecosystem of the natural habitat of wild nutmeg. The natural habitat of wild nutmeg is classified as having a stable ecosystem with minimum disturbance, moderately abundant, and high vegetation species richness.**

Keywords*— Vegetation analysis; natural habitat; wild nutmeg; *Myristica spp.

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I. Introduction

Nutmeg (*Myristica, spp*.) is a spice plant in the form of a tree originating from the Maluku Islands and known as a native plant from Indonesia. The *Myristicaceae* family has fruit that contains nutmeg oil (*myristicin*) so it can be used as a medicinal ingredient [1],[2], food and beverage preservatives [2] as well as antimicrobials or bioinsecticides [3], [4],[5].

The dominant type of nutmeg cultivated by Indonesian farmers is Banda nutmeg (*Myristica fragrans HOUTT)* because the highest volatile oil content [5],[6] and Patani nutmeg (*Myristica succedanea* BL) produces essential oils from leaves, fruit pulp, seeds and mace 0.32%, 0.03%, 2.89% and 2.36% respectively [7]. Apart from Banda nutmeg and Patani nutmeg, 430 accession numbers of nutmeg were found which were also cultivated by farming communities on the smallholder plantation scale [8], [9].

The nutmeg commodity in North Maluku is produced from the cultivated population of nutmeg and the yield of the population of wild nutmeg that grows in natural habitats in the forests of Halmahera and Bacan islands, but information on population structure, distribution pattern, and genetic diversity of wild nutmeg is still limited and has not been reported in previous studies. Wild plant populations are an important source of genes to increase the commercial value of a variety [10], [11]

On Halmahera Island, North Maluku, wild nutmeg was used by people living near the forest by harvesting the fruit which produces seeds and mace which have high economic value and are used as a source of seeds. The pattern of harvesting wild nutmegs is regulated based on the local wisdom of the local community, while the seeds used are seeds that are considered of high quality, or uprooted seeds. However, shifting farming patterns and the development of mining areas cause land degradation and deforestation [12] which can threaten the germplasm of wild nutmeg populations. Utilization of wild population germplasm must be accompanied by efforts to conserve and protect it to avoid genetic erosion [13].

Exploration of wild nutmeg populations in natural habitats was carried out to determine population structure based on vegetation analysis, and preferences for growth factors used as a basis for consideration of conservation and management of wild nutmeg population germplasm, as well as preservation of wild plant resources on Halmahera Island. Analyzed the vegetation to determine the floristic composition of species, life forms [14], diversity [15], and community structure about edaphic variables [16].

Vegetation studies were conducted to determine the species composition and vegetation structure of wild nutmeg populations in the natural habitat of the Halmahera forest. Defines vegetation composition as a floristic list of vegetation types that exist in a community, and vegetation structure is the result of spatial planning by the components of the stand and life forms, stratification, and vegetation cover as described by the condition of diameter, height, spatial distribution, canopy diversity, and species continuity [17],[18]

Vegetation studies are useful for the development of economic value, tree potential, and plant production. One of the potentials of wild nutmeg is its biological value, especially related to the source of planting material or genes. Vegetation assessment results will increase the effectiveness of the evaluation and conservation of the genetic diversity of wild plants and ensure the availability of sustainable planting material [19]. Conservation of plant genetic diversity can be done through the identification of plant morphology, such as mangosteen, Local durio [20], and diversity of nutmeg species (*myristica spp.)* North Maluku [8].

Vegetation analysis was carried out to make the basis of the conservation of wild nutmeg in natural habitats because it obtained information about population composition and structure, plant diversity, and interspecific associations of wild nutmeg with other plant species. Therefore, this research was conducted to identify the composition and vegetation structure of the wild nutmeg natural habitat in Halmahera Island Forest, to provide a *database* for the development of wild nutmeg germplasm conservation, both *in-situ and ex-situ.*

II. MATERIALS AND METHOD

A. Study Area

Vegetation research on wild nutmeg populations was conducted in forest areas in Central Halmahera and East Halmahera Regencies, North Maluku Province. Geographically, Central Halmahera is between 0°45' North Latitude–0°15' South Latitude and 127°45'–129°26' East Longitude. Central Halmahera Regency's total area is 8,381.48 km² (2,276.83 km² land area, 6,104.65 km² sea area) . While the area of East Halmahera Regency is at 1° 4'-0° 40' South Latitude and 126° 45'-130° 30' East Longitude (Fig. 1).

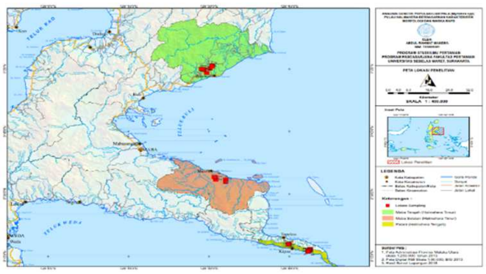

Fig. 1 The Location of Study Area

B. Data Collection and Data Analysis

Determination of the sampling location of wild nutmeg populations was carried out using a *purposive sampling method*, namely village forests where wild nutmeg populations grow in East Halmahera and Central Halmahera Regencies. The number of population samples was determined *using snowball sampling,* based on informants' recommendations. The method used in the analysis of wild nutmeg population vegetation uses a sampling method with a sampling technique without plots *(plotless sampling technique).* This method utilizes the measurement of the distance between individual plants or the distance from a randomly selected tree to the particular plants closest to the observation point, assuming the individual plants spread randomly.

One of the most efficient *plotless sampling techniques* is the Point *Centered Quartered Method* because its implementation in the field requires less time, is easier, and does not require a correction factor in estimating the density of individual plants, although has limitations, namely that each quadrant must have at least one individual plant and each individual cannot be counted more than once [21],[22]. The procedure for this method in implementation in the field is:

a. Placing several sample points randomly in the plant community. Beginning with drawing a compass direction line (pilot line) in a community with a wild nutmeg population, several sample points are chosen randomly or regularly along the pioneering line. The planned sample points are at least 20 sample points srove sampling accuracy.
b. The division of the area around the sample point into four quadrants of equal size (Fig. 2), is carried out using a compass, or if a series of pathways is used the quadrants can be formed using the pathway itself and a line perpendicular to the pathway through example point.
c. An imaginary abscissa and ordinate line are made for each measurement point so that at each measurement point there are four quadrants. The observed trees are the trees in each quadrant that are closest to the measurement point, then the distance from each tree to the measurement point is measured. Tree dimensions were only measured for the four selected trees.

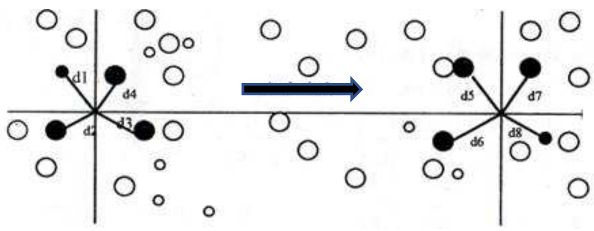

Fig. 2 Point-centered quarter method design

The analysis of vegetation in the habitat of wild nutmeg is calculated as follows:

d. The average distance of individual trees to the measurement point

$$d' = \frac{d1+d2+\cdots+dn}{n} \quad (1)$$

e. Density (De)

$$\text{De} = \frac{Unit\ Area}{(d')^2} \quad (2)$$

$$d \approx Basal\ area = \left(\frac{1}{2}d\right)^2 \prod$$

f. Relative density (RDe)

$$\text{RDe} = \frac{Number\ of\ Individuals\ of\ a\ Type}{Number\ of\ Individuals\ of\ All\ Types}\ x\ 100\% \quad (3)$$

g. The density of a Type (DeT)

$$\text{DeT} = \frac{RDe \times De}{100} \quad (4)$$

h. Dominance (Do)

$$Do = DeT\ \times Average\ Dominance\ Per\ Type \quad (5)$$

i. Relative dominance (RDo)

$$\text{RDo} = \frac{Do}{Dominance\ of\ all\ types} \times 100\% \quad (6)$$

j. Frequency (F)

$$\text{F} = \frac{Number\ of\ Points\ Found\ by\ a\ Type}{Sum\ of\ All\ Measurement\ Points}\ \text{x}\ 100\% \quad (7)$$

k. Relative frequency (Rf)

$$\text{Rf} = \frac{F}{Frequency\ of\ all\ types} \quad (8)$$

l. Important Value Index (IVI)

$$IVI = RDe\ + RDo + Rf \quad (9)$$

m. Shanon-Wienner Diversity Index (H')

$$\text{H}' = -\sum \left[\left(\frac{ni}{N}\right) ln \left(\frac{ni}{N}\right)\right] \quad (10)$$

n. Species richness Margaleff (R')

$$\text{R}' = \sum_{k=1}^{n} \left(\frac{S-1}{ln\ N}\right) \quad (11)$$

o. Species evenness Pielou (E)

$$\text{E} = \frac{H'}{\ln S} \quad (12)$$

III. Results and Discussion

A. Importance Value Index

The natural habitat of wild nutmeg was defined as a place where the whole period of growth and development of the forest plant goes through the same place. Results of vegetation analysis found 44 species of wild nutmeg in the natural habitat of Halmahera Island Forest (Table 1). All species found are species in the tree category. Species in the seedling and pole categories were not included in this analysis because they were not suitable for the application of the sampling method with a *plotless sampling technique* [21]. The recorded vegetation types were derived from the results of vegetation analysis on wild nutmeg habitat at 3 observation points, namely 2 points (Wayamli: 1° 00' - 0° 59' South Latitude and 128° 30' - 128° 22' East Longitude and Maba Bicoli : 0° 33' - 0° 42' S and 128° 30' - 128° 31' E) in East Halmahera Regency and 1 point (Patani: 0° 16' - 0° 17' S and 128° 44' - 128° 48' East) in Central Halmahera Regency.

The important value index (IVI) parameter provides a quantitative and qualitative description of the role of the species in question in the community [18], [23]. Differences in the composition and structure of vegetation within a community are influenced by vegetation phenology, dispersal, and natality [24], [25]. Wild nutmeg (*Myristica spp*) vegetation found in natural habitats on Halmahera Island had the highest important value index (IVI) (54.75%), followed successively by *Euterpe edulis* (44.15%), *Agathis spp* (9.03 %), and *Macharanga spp* (8.25%). So, these plants are constituents of vegetation that dominate the region [26].

TABLE I
IMPORTANCE VALUE INDEX OF VEGETATIONS IN NATURAL HABITAT OF WILD NUTMEG (MYRISTICA SPP) IN HALMAHERA FOREST, NORTH MALUKU.

No.	Vegetations were Observed	RDe %	RDo %	RF %	IVI %
1	*Myristica spp*	29.4	25.16	0.15	54.75
2	*Euterpe edulis*	9.3	34.73	0.08	44.15
3	*Agathis spp*	7.5	1.5	0.05	9.03
4	*Macaranga sp*	1.4	6.82	0.02	8.25
5	*Dracontomelon dao*	3.7	2.16	0.04	5.94
6	*Palaquium obtusifolium*	3.7	2.02	0.04	5.79
7	*Shorea sp*	1.4	3.61	0.01	5.03
8	*Pometia pinnata*	4.2	0.61	0.06	4.88
9	*Cannarium hirsutum*	2.8	1.92	0.05	4.77
10	*Adina fogifolia*	3.3	1.01	0.03	4.31
11	*Callophylum spp*	1.4	1.76	0.02	3.18
12	*Duabanga moluccana*	2.8	0.2	0.03	3.04
13	*Mangipera sp*	1.9	1.06	0.03	2.95
14	*Tristania sp*	0.9	1.8	0.01	2.74
15	*Anthocepalus chinensis*	2.3	0.35	0.03	2.71
16	*Homalium foetidum*	2.3	0.2	0.03	2.57
17	*Alstonia scholaris*	1.4	1.05	0.02	2.47
18	*Cinnamomum culilawan*	0.9	1.22	0.01	2.16
19	*Gnetum gnemon*	0.5	1.38	0.01	1.86
20	*Alstonia angustiloba*	1.4	0.43	0.02	1.85
21	*Intsia bijuga*	0.9	0.9	0.01	1.85
22	*Mangifera minor*	0.9	0.83	0.01	1.77
23	*Hibiscus tiliaceus*	0.5	1.29	0.01	1.77
24	*Litsea angulata*	0.9	0.7	0.01	1.64
25	*Vitex cofassus*	1.4	0.12	0.02	1.54
26	*Anisopthera thrurifera*	1.4	0.08	0.02	1.5
27	*Ficus benyamina*	1.4	0.05	0.02	1.48
28	*Dillenia spp*	0.5	0.99	0.01	1.46
29	*Gmelina moluccana*	0.5	0.87	0.01	1.34
30	*Arengapinnata*	0.5	0.77	0.01	1.24
31	*Gluta renghas*	0.5	0.77	0.01	1.24
32	*Lagruceae sp*	0.9	0.29	0.01	1.24
33	*Petrocarpus indica*	0.5	0.61	0.01	1.09
34	*Piper aduncum*	0.5	0.61	0.01	1.08
35	*Artocarpus elasticus*	0.5	0.61	0.01	1.08
36	*Myristica iners*	0.9	0.12	0.01	1.06
37	*Mimusops elengi*	0.9	0.07	0.01	1.02
38	*Heritera sylfalica*	0.5	0.51	0.01	0.99
39	*Vatica Papuana*	0.9	0.04	0.01	0.98
40	*Syzygium polyanthum*	0.5	0.31	0.01	0.78
41	*Aglaia sp*	0.5	0.28	0.01	0.75
42	*Hopea novoguineensis*	0.5	0.13	0.01	0.61
43	*Quercus sp*	0.5	0.06	0.01	0.53
44	*Paraserianthes falcataria (L.)*	0.5	0.02	0.01	0.49
Sum.		**100**	**100**	**1**	**201**

B. Density and Basal Area of Vegetation in the Natural Habitat of Wild Nutmeg

The study's results revealed that the density of tree vegetation was determined by each individual's basal area, as shown in Table 2. The individual density per unit area is inversely proportional to the individual's basal area, so the larger the basal area, the smaller the individual density, and conversely, the individual density is high if the individual's basal area is low.

TABLE II
DENSITY AND BASAL AREA OF VEGETATIONS IN NATURAL HABITAT OF WILD NUTMEG (MYRISTICA SPP) IN HALMAHERA FOREST, NORTH MALUKU

No	Proportion of the Density (De) and Basal Area (BA)					
	Vegetations were Observed	De	BA m2	Vegetations were Observed	De	BA m2
1	*Macaranga sp*	2457.9	0.02	*Ficus benyamine*	19.2	0.23
2	*Euterpe edulis*	1876	0.02	*Vatica Papuana*	20.8	0.22
3	*Gnetum gnemon*	1494.4	0.03	*Paraserianthes falcataria (L.)*	21.3	0.22
4	*Hibiscus tiliaceus*	1394	0.03	*Anisopthera thrurifera*	28.5	0.19
5	*Shorea sp*	1301.9	0.03	*Duabanga moluccana*	35.7	0.17
6	*Dillenia spp*	1067.6	0.03	*Mimusops elengi*	38.8	0.16
7	*Tristania sp*	970.3	0.03	*Vitex cofassus*	42.3	0.15
8	*Gmelina moluccana*	940.3	0.03	*Homalium foetidum*	43.5	0.15
9	*Gluta renghas*	831.4	0.03	*Myristica iners*	62.6	0.13
10	*Arengapinnata*	831.4	0.03	*Quercus sp*	64.6	0.12
11	*Cinnamomum culilawan*	657	0.04	*Pometia pinnata*	73.3	0.12
12	*Petrocarpus indica*	657	0.04	*Anthocepalus chinensis*	75.1	0.12
13	*Piper aduncum*	657	0.04	*Agathis spp*	101.2	0.1
14	*Artocarpus elasticus*	657	0.04	*Hopea novoguineensis*	145.7	0.08
15	*Callophylum spp*	632.6	0.04	*Alstonia angustiloba*	155.7	0.08
16	*Heritera sylfalica*	555.5	0.04	*Adina fogifolia*	156	0.08
17	*Intsia bijuga*	485.5	0.05	*Lagruceae sp*	157.8	0.08
18	*Mangifera minor*	448.8	0.05	*Palaquium obtusifolium*	272.2	0.06
19	*Alstonia scholaris*	378.8	0.05	*Mangiper sp*	285.1	0.06
20	*Litsea angulata*	375.7	0.05	*Dracontomelon dao*	291.8	0.06
21	*Cannarium hirsutum*	346.1	0.05	*Aglaia sp*	302.2	0.06
22	*Syzygium polyanthum*	332.4	0.05	*Myristica Spp*	431.4	0.05

C. Basal Area, Dominance, and Importance Value Index

The types of *Pometia pinnata* and *Duabanga moluccana* have a relatively large basal area and IVI but a small dominance level (Table 3), namely *Pometia pinnata* (136.4 m ^{2}: 4.88: 0.48), and Duabanga *moluccana* (280.2 m ^{2} : 3.04: 0.16). This indicates the presence of *Pometia pinnata* and *Duabanga moluccana species* with large diameters effect on environmental factors in the natural habitat of wild nutmeg, although in a limited number of stands. The success of each type of vegetation to occupy an area is influenced by its ability to adapt optimally to all physical environmental factors (temperature, light, soil structure, humidity), biotic factors (interactions between species, competition, parasitism), and chemical factors which include water availability, oxygen, pH, nutrients in the soil that interact with each other [19], [30]

D. Dominance and Importance Value Index

Myristica spp, Euterpe edulis, and *Macaranga sp* are vegetation types in the natural habitat of wild nutmeg with high dominance and IVI (Table 4), namely *Myristica spp* (19.71: 54.75)*, Euterpe edulis* (27.12: 44, 15)*,* and *Macaranga sp* (5.35: 8.25). The association of the three vegetation specifically describes the natural habitat conditions of wild nutmeg, as follows:

First, the association between *Myristica spp* and *Euterpe edulis* illustrates the conditions of phenological similarity [17] between the two species, namely the similarity of the influence of the surrounding environment, such as the duration of irradiation, temperature, and humidity on the ongoing period of phases that occur naturally in both plants. the. In the field, *Myristica spp* and *Euterpe edulis* were found in most of the same plots. Thus, *Euterpe edulis* can be used as an indicator of the uniqueness of the wild nutmeg natural habitat.

TABLE III
PROPORTION BASAL AREA, DOMINANCE AND IVI OF VEGETATIONS IN NATURAL HABITAT OF WILD NUTMEG (MYRISTICA SPP) IN HALMAHERA FOREST, NORTH MALUKU

Vegetations were Observed	BA m2	Do	IVI %
Ficus benyamine	0.23	0.04	1.48
Vatica Papuana	0.22	0.03	0.98
Paraserianthes falcataria (L.)	0.22	0.02	0.49
Anisopthera thrurifera	0.19	0.06	1.5
Duabanga moluccana	0.17	0.16	3.04
Mimusops elengi	0.16	0.06	1.02
Vitex cofassus	0.15	0.09	1.54
Homalium foetidum	0.15	0.16	2.57
Myristica iners	0.13	0.09	1.06
Quercus sp	0.12	0.05	0.53
Pometia pinnata	0.12	0.48	4.88
Anthocepalus chinensis	0.12	0.27	2.71
Agathis spp	0.1	1.17	9.03
Hopea novoguineensis	0.08	0.11	0.61
Alstonia angustiloba	0.08	0.34	1.85
Adina fogifolia	0.08	0.79	4.31
Lagruceae sp	0.08	0.23	1.24
Palaquium obtusifolium	0.06	1.58	5.79
Mangiper sp	0.06	0.83	2.95
Dracontomelon dao	0.06	1.69	5.94
Aglaia sp	0.06	0.22	0.75
Euterpe edulis	0.02	27.21	44.15
Macaranga sp	0.02	5.35	8.25

Second, the association between *Myristica spp* and *Macaranga sp* illustrates that the natural habitat ecosystem of wild nutmeg has changed the composition and structure of its natural vegetation. Human/societal intervention is the main factor causing these changes [31]. Communities around the forest tend to reduce the vegetation that grows around *Myristica spp* to facilitate harvesting. Reducing vegetation around wild nutmeg vegetation creates open space and facilitates the growth of secondary vegetation, such as

Macaranga sp. More massive vegetation reduction measures (reduction at the seedling and pole levels) occurred at the Maba-Bicoli and Patani observation points so that what remains are vegetation/trees with commercial tree qualifications, such as *Homalium foetidum, Cannarium hirsutum, Dracontomelon dao, Alstonia angustiloba,* and *Shorea sp.*

E. The Density of Species and Dominance

The types of vegetation with the highest species density and dominance are *Myristica spp, Palmae spp, Agathis spp, Macaranga sp, Dracontomelon dao, Palaquium obtusifolium, Shorea sp, Cannarium hirsutum,* and *Adina fogifolia* are shown in Table 4. The density determines the dominance level of each species [32] and diameter of the trees, which correlate with the land cover area (basal area). Thus, the dominant vegetation types utilize most of the resources in the wild nutmeg habitat ecosystem. The distribution of species, density, and dominance of a plant has a very real correlation with the place where it grows or its habitat [33], [34].

TABLE IV
VEGETATION WITH THE HIGHEST SPECIES DENSITY AND DOMINANCE IN THE NATURAL HABITAT OF WILD NUTMEG (MYRISTICA SPP) IN HALMAHERA FOREST, NORTH MALUKU

Vegetations were Observed	**Local Name**	**DeT**	**Do**
Euterpe edulis	Palem	175.3	27.21
Macaranga sp	Same	34.5	5.35
Shorea sp	Meranti	18.3	2.83
Dracontomelon dao	Bua Rau	10.9	1.69
Palaquium obtusifolium	Nyato	10.2	1.58
Cannarium hirsutum	Kanari	9.7	1.51
*Myristica spp *)*	Nutmeg	127	19.71

Note: DeT= Density of Species, D=Dominance, *) insert

F. Diversity and Richness of Vegetation Types in the Natural Habitat of Wild Nutmeg

The components of biodiversity of wild nutmeg natural habitat in Halmahera Forest, North Maluku, namely species diversity (H'), species richness (R), and evenness of species (E), have index values of moderate abundance of species diversity (H'=2.99), high species richness (R'=31.68), and medium category evenness (E=0.55) are shown in Table 5.

TABLE V
BIODIVERSITY OF VEGETATION IN THE NATURAL HABITAT OF WILD NUTMEG IN HALMAHERA, NORTH MALUKU

Parameter of Diversity	**Category**
Shanon-Wienner Diversity Index (H')	**2.96 (** H' $1 \leq H \leq 3$)
Species richness Margaleff (R')	**31.68 (**R' > 5)
Species evenness Pielou (E)	**0.55 (**$0.3 < E < 0.6$)

The biodiversity component is influenced by the condition of natural communities in the form of the biodiversity of plants [35], animals [36], and microorganisms [37], soil type, geology, climate, variations in altitude, and rainfall [29] but is also influenced by human involvement, such as the discourse between economic and ecological interests [38], and conversion of forests to agroforestry [39]. Changes in the composition and structure of forest vegetation are strongly influenced by disturbances, both natural and anthropogenic [10], [29].

IV. CONCLUSION

A wide expanse of basalt vegetation can support the growth and development of wild nutmeg (*Myristica* spp.), which includes the kinds of *Ficus benyamina, Vatica Papuana, Paraserianthes falcataria, Vitex cofassus,* and *Mimusops elengi*. Even within a small number of tree stands, the composition and environmental conditions of the wild nutmeg (*Myristica* spp.) natural habitat can be influenced by the types of *Pometia pinnata* and *Duabanga moluccana*.

The vegetation types with high dominance and IVI in wild nutmeg natural environments are *Myristica* spp., *Euterpe edulis,* and *Macaranga* spp. While *Macaranga* sp. is a predictor of changes in the environment of the wild nutmeg's (*Myristica* spp.) natural habitat. *Euterpe edulis* can be utilized as an indicator of the uniqueness of the natural habitat. The natural habitat of wild nutmeg has a high species richness of flora and a reasonably plentiful diversity of vegetation types. The natural habitat for wild nutmeg in the Halmahera Forest, North Maluku, is categorized as stable with a low degree of disturbance due to the even distribution of vegetation types in the moderate category.

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REFERENCES

[1] I. Matulyte, A. Mataraite, S. Velziene, and J. Bernatoniene, "The Effect of Myristica fragrans on Texture Properties and Shelf-Life of Innovative Chewable Gel Tablets," *Pharmaceutics*, vol. 13, no. 2, p. 238, Feb. 2021, doi: 10.3390/pharmaceutics13020238.

[2] R. Barman et al., "Nutmegs and wild nutmegs: An update on ethnomedicines, phytochemicals, pharmacology, and toxicity of the Myristicaceae species," *Phytotherapy Research*, vol. 35, no. 9, pp. 4632–4659, May 2021, doi: 10.1002/ptr.7098.

[3] V. Adiani, S. Gupta, S. Chatterjee, P. S. Variyar, and A. Sharma, "Activity guided characterization of antioxidant components from essential oil of Nutmeg (Myristica fragrans)," *Journal of Food Science and Technology*, vol. 52, no. 1, pp. 221–230, May 2013, doi:10.1007/s13197-013-1034-7.

[4] A. Badr et al., "Genetic diversity and volatile oil components variation in Achillea fragrantissima wild accessions and their regenerated genotypes," *Journal of Genetic Engineering and Biotechnology*, vol. 19, no. 1, p. 166, Dec. 2021, doi: 10.1186/s43141-021-00267-3.

[5] G. Arumugam, B. Purushotham, and M. K. Swamy, "Myristica fragrans Houtt.: Botanical, Pharmacological, and Toxicological Aspects," *Natural Bio-active Compounds*, pp. 81–106, 2019, doi:10.1007/978-981-13-7205-6_4.

[6] T. Ulfah, H. H. Hardjomidjodjo, and E. Anggraeni, "Nutmeg determination as the main commodity in South Aceh; a literature review," *IOP Conference Series: Earth and Environmental Science*, vol. 472, no. 1, p. 012040, Apr. 2020, doi: 10.1088/1755-1315/472/1/012040.

[7] T. J. Zachariah and N. K. Leela, "Volatiles from herbs and spices," *Handbook of Herbs and Spices*, pp. 177–218, 2006, doi:10.1533/9781845691717.2.177.

[8] S. Das, S. Sudarsono, H. M. H. Djoefrie, and Y. Wahyu, "Diversity of Nutmeg Species (Myristica spp.) in North Moluccas based on the Morphological and Agronomic Markers," *Jurnal Penelitian Tanaman Industri (Jurnal Littri)*, vol. 18, pp. 1–9, Mar. 2012.

[9] A. Gordon, "Market & technical considerations for spices: Nutmeg & Mace case study," *Food Safety and Quality Systems in Developing Countries*, pp. 367–414, 2020, doi: 10.1016/b978-0-12-814272-1.00009-7.

[10] S. Eddy, I. Dahlianah, C. Mashito, M. Oktavia, and B. Utomo, "Anthropogenic implications for land cover changes and vegetation structure in coastal protected forest," *Biodiversitas Journal of*

Biological Diversity, vol. 23, no. 9, Sep. 2022, doi:10.13057/biodiv/d230913.
[11] C. Zhang et al., "Genetic diversity and population structure of Chinese Gizzard Shad Clupanodon thrissa in South China based on morphological and molecular markers," *Global Ecology and Conservation*, vol. 41, p. e02367, Jan. 2023, doi:10.1016/j.gecco.2023.e02367.
[12] R. Juniah, M. T. Toha, S. Zakir, and H. Rahmi, "Potential Economic Value of Water Resource Sustainability for Sustainable Environment: A Case Study in South Sumatra, Indonesia," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 13, no. 1, pp. 165–172, Jan. 2023, doi: 10.18517/ijaseit.13.1.16223.
[13] G. Acquaah, Principles of Crop Production: Theory, Techniques, and Technology, 2nd ed. Upper Saddle River, NJ, USA: Pearson Prentice Hall, 2005.
[14] K. Abdel Khalik, M. El-Sheikh, and A. El-Aidarous, "Floristic diversity and vegetation analysis of Wadi Al-Noman, Mecca, Saudi Arabia," *Turkish Journal of Botany*, vol. 37, pp. 894–907, 2013, doi:10.3906/bot-1209-56.
[15] K. Rawal and P. B. Subedi, "Vegetation structure and carbon stock potential in the community-managed forest of the Mid-Western Hilly Region, Nepal," *Asian Journal of Forestry*, vol. 6, no. 1, Jun. 2022, doi: 10.13057/asianjfor/r060103.
[16] M. Jannat, Md. Kamruzzaman, and M. K. Hossain, "Tree species diversity and structural composition of village common forest in Bandarban District, Bangladesh," *Asian Journal of Forestry*, vol. 4, no. 2, Aug. 2020, doi: 10.13057/asianjfor/r040205.
[17] S. Lahoti, A. Lahoti, R. K. Joshi, and O. Saito, "Vegetation Structure, Species Composition, and Carbon Sink Potential of Urban Green Spaces in Nagpur City, India," *Land*, vol. 9, no. 4, p. 107, Apr. 2020, doi: 10.3390/land9040107.
[18] B. Workayehu, D. Fitamo, F. Kebede, L. Birhanu, and A. Fassil, "Floristic Composition, Diversity, and Vegetation Structure of Woody Species in Kahitassa Forest, Northwestern Ethiopia," *International Journal of Forestry Research*, vol. 2022, pp. 1–12, Dec. 2022, doi:10.1155/2022/7653465.
[19] R. H. S. Siburian, R. Angrianto, A. Murdjoko, and A. Tampang, "The Characteristics of Growing Sites of Myristicaceae in Momiwaren Protected Forest Area, South Manokwari – West Papua, Indonesia," *Journal of critical reviews*, vol. 7, no. 03, Jan. 2020, doi:10.31838/jcr.07.03.44.
[20] E. Yuniastuti, A. Anggita, Nandariyah, and Sukaya, "Local durian (Durio zibethinus murr.) exploration for potentially superior tree as parents in Ngrambe District, Ngawi," *IOP Conference Series: Earth and Environmental Science*, vol. 142, p. 012029, Mar. 2018, doi:10.1088/1755-1315/142/1/012029.
[21] A. Navarro, "Plotless Sampling," in Introduction to Ecological Sampling, J. A. Manly and A. Navarro, Eds. Boca Raton, FL, USA: CRC Press, 2015.
[22] X. Zhu and J. Zhang, "Quartered neighbor method: A new distance method for density estimation," *Frontiers of Biology in China*, vol. 4, no. 4, pp. 574–578, Jul. 2009, doi: 10.1007/s11515-009-0039-0.
[23] Z. Zulfikar, E. Arisoesilaningsih, S. Indriyani, and A. A. R. Fernandes, "Biodiversity index of fruit trees cultivated by communities around marginal land in Jombang Regency, East Java Province, Indonesia," *IOP Conference Series: Earth and Environmental Science*, vol. 743, no. 1, p. 012049, May 2021, doi: 10.1088/1755-1315/743/1/012049.
[24] F. B. Kali, Z. Kusuma, and A. S. Leksono, "Diversity of Vegetation Around the Springs to Support Water Resource Conservation In Belu, East Nusa Tenggara, Indonesia," *J. Biodivers. Environ. Sci.*, vol. 6, no. 4, pp. 100–114, 2015.
[25] W. Vasquez-Castillo, K. Ayala, M. Almeida, A. F. Barrientos-Priego, P. Moncayo-Moncayo, and Á. Monteros-Altamirano, "Morphological in situ Characterization of Mortiño (Vaccinium floribundum Kunth) in the Andes of Ecuador," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 12, no. 5, pp. 1714–1720, Sep. 2022, doi: 10.18517/ijaseit.12.5.15157.
[26] J. Z. Muddin *et al.*, "Struktur Dan Komposisi Tumbuhan Berkayu Di Kawasan Hutan Gunung Tondong Karambu, Kabupaten Bone," *J. ABDI Sos. Budaya dan Sains*, vol. 3, no. 1, pp. 99–113, 2021.
[27] T. Zhao et al., "Functional diversity patterns reveal different elevations shaping Himalayan amphibian assemblages, highlighting the importance of morphologically extreme individuals," *Ecological Indicators*, vol. 150, p. 110260, Jun. 2023, doi:10.1016/j.ecolind.2023.110260.
[28] X. Niu et al., "Understanding vegetation structures in green spaces to regulate atmospheric particulate matter and negative air ions," *Atmospheric Pollution Research*, vol. 13, no. 9, p. 101534, Sep. 2022, doi: 10.1016/j.apr.2022.101534.
[29] J. M. Fernández-Guisuraga, P. M. Fernandes, R. Tárrega, D. Beltrán-Marcos, and L. Calvo, "Vegetation recovery drivers at short-term after fire are plant community-dependent in mediterranean burned landscapes," *Forest Ecology and Management*, vol. 539, p. 121034, Jul. 2023, doi: 10.1016/j.foreco.2023.121034.
[30] H. H. Jones and S. K. Robinson, "Patch size and vegetation structure drive changes to mixed-species flock diversity and composition across a gradient of fragment sizes in the Western Andes of Colombia," *The Condor*, vol. 122, no. 2, Mar. 2020, doi: 10.1093/condor/duaa006.
[31] B. Zimbres et al., "Savanna vegetation structure in the Brazilian Cerrado allows for the accurate estimation of aboveground biomass using terrestrial laser scanning," *Forest Ecology and Management*, vol. 458, p. 117798, Feb. 2020, doi: 10.1016/j.foreco.2019.117798.
[32] S. M. Kiasari, K. S. Talebi, R. Rahmani, and H. Ghelichnia, "Comparison of plant diversity between managed and unmanaged forests in Haftkhal, Mazandaran Province, North of Iran," *Asian Journal of Forestry*, vol. 7, no. 2, Jul. 2023, doi:10.13057/asianjfor/r070205.
[33] G. Rutten, A. Ensslin, A. Hemp, and M. Fischer, "Vertical and Horizontal Vegetation Structure across Natural and Modified Habitat Types at Mount Kilimanjaro," *PLoS ONE*, vol. 10, no. 9, p. e0138822, Sep. 2015, doi: 10.1371/journal.pone.0138822.
[34] H. Sun et al., "Vegetation Change and Its Response to Climate Change in Yunnan Province, China," *Advances in Meteorology*, vol. 2021, pp. 1–20, Jan. 2021, doi: 10.1155/2021/8857589.
[35] G. Boz and M. Maryo, "Woody Species Diversity and Vegetation Structure of Wurg Forest, Southwest Ethiopia," *International Journal of Forestry Research*, vol. 2020, pp. 1–17, Oct. 2020, doi:10.1155/2020/8823990.
[36] L. A. Do Nascimento, M. Campos-Cerqueira, and K. H. Beard, "Acoustic metrics predict habitat type and vegetation structure in the Amazon," *Ecological Indicators*, vol. 117, p. 106679, Oct. 2020, doi:10.1016/j.ecolind.2020.106679.
[37] M. Sraun, R. Bawole, J. Marwa, A. S. Sinery, and R. L. Cabuy, "Diversity, composition, structure and canopy cover of mangrove trees in six locations along Bintuni riverbank, Bintuni Bay, West Papua, Indonesia," *Biodiversitas Journal of Biological Diversity*, vol. 23, no. 11, Nov. 2022, doi: 10.13057/biodiv/d231137.
[38] Y. Malhi et al., "Climate change and ecosystems: threats, opportunities and solutions," *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 375, no. 1794, p. 20190104, Jan. 2020, doi:10.1098/rstb.2019.0104.
[39] A. P. P. Hartoyo, A. Sunkar, R. Ramadani, S. Faluthi, And S. Hidayati, "Normalized Difference Vegetation Index (NDVI) analysis for vegetation cover in Leuser Ecosystem area, Sumatra, Indonesia," *Biodiversitas Journal of Biological Diversity*, vol. 22, no. 3, Feb. 2021, doi: 10.13057/biodiv/d220311.