WOODY PLANT DIVERSITY IN TROPICAL MOIST EVERGREEN CLOSED FOREST IN TAN PHU FOREST, DONG NAI PROVINCE

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SUMMARY

Plant diversity plays an important role in maintaining the protective and useful functions of the forest. This study aims to determine the diversity of woody plants as a basis for proposed solutions for the conservation of plant resources in the Tan Phu Forest, Dong Nai province. A total of 45 sample plots were divided equally into 3 forest states; Primer 6.1.6 and the SPSS 23 software were also used for the data analysis. The study showed that a total of 114 woody plant species of 89 genera belonging to 41 families were documented. There were 33 species (28.95%) were identified as threatened. Of these, 7 species were listed in Vietnam's Red Data Book (2007), 3 species in Government Decree 06/2019, and 32 species in the IUCN Red List (2021). The number of ecologically significant species and ecologically dominant groups ranged from 19 to 20 species and 4 to 5 species, respectively. The diversity indices of Magarlef (d), Pielou (J'), Shannon-Weiner (H'), and Simpson (Cd) showing that the diversity of the woody plants was low. Most of the species analyzed (70.77 - 91.95%) had a regular distribution. *Dalbergia cochinchinensis, Dalbergia oliveri, Knema pierrei, Aporosa microstachia*; communities 17 and 43; and poor forest status was considered independently and unrelated to other species, communities, and states. It was also recommended that the suitable plot size for the list of woody species be greater than 45 plots. The results of this study provide a reliable scientific basis for the strategy for the management and conservation of forest resources, which helps to improve the use and effectiveness of the protective function of the forest in the study area.

Keywords: cluster diagram, diversity, Nonmetric Multi-Dimensional Scaling (MDS), Tan Phu, woody plant.

1. INTRODUCTION

Assessing biodiversity to determine the structure, function of an ecosystem and changes within ecosystems, protect genetic reserves, control environmental changes, and identify the best conservation of biodiversity has attracted the attention of numerous scientists (Burely, 2002).

The Tan Phu Forest in Dong Nai province is one of the typical tropical moist evergreen closed forests of the southeast region. This place is not only rich in tree species and non-non-timber forest products, but it is also of great importance in terms of science, economy, defense, and the environment. The main function of the Tan Phu forest is to protect the soil, regulate the climate, protect biodiversity and the ecological environment, and regulate the water source for the Tri An hydropower plant (Le Van Long *et al.,* 2020). The diversity of plants in general and woody plants in particular therefore plays an important role in maintaining and promoting the function of the forests.

The studies carried out in Tan Phu mainly relate to the silvicultural, regenerative, ecological properties of the plant communities and some tree species of the Dipterocarpaceae family. In addition to the analysis of genetic diversity, studies on medicinal plants were also documented. However, studies on plant diversity in general and on wood plant diversity in particular in the Tan Phu forest have not been investigated to date. This study aims to determine the composition, diversity, spatial distribution, relationships between species and communities to select species and plant communities that need to be prioritized for protection.

2. RESEARCH METHODOLOGY

2.1. Study sites

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This study was conducted in Tan Phu Forest, Dong Nai province (from 110232 N to 10702730 E) from November 2020 to March 2021. The total area was approx. 13,862.2 hectares and belongs to the tropical monsoon climate (sunny and rainy seasons). The average air temperature was 25ºC per year. The average annual rainfall was 2,100 mm. The average air humidity was 80% per year. The altitude of the terrain was 80 m to 120 m above sea level. The Tan Phu forest was characterized by a tropical moist evergreen closed forest. The main composition was represented by *Shorea roxburghii, Dipterocarpus alatus, D. costatus, D. dyeri, D. intricatus, D. turbinatus, Anisoptera costata, Hopea odorata*, and some species of *Lagerstroemia spp., Diospyros spp., Syzygium spp., Knema spp., Vitex spp*. etc (Nguyen Van Hop *et al.,* 2020).

2.2. Methodology

2.2.1. Field survey

A total of 45 sample plots (25m x 20m) were established and evenly equally divided into 3 forest states (15 plots per state): rich, medium, and poor of the tropical moist evergreen closed forest. The location of each sample plot was determined with a GPS tracking device. In each sample plot, information was collected on common names, the number of individuals, the diameter at breast height (DBH ≥ 5 cm), and the overall height (Hvn) of each tree.

2.2.2. Data analysis

The forest status was determined as follows rich forest: volume > 200 (cubic meters/ha); medium forest: 100 < volume ≤ 200 (cubic meters/ha); poor forest: 50 < volume ≤ 100 (cubic meters/ha) (Circular No. 33/2018/TT-BNNPTNT, 2018). The name of the species was identified by the method of comparative morphology. The documents were used to identify plant species: An Illustrated Flora of Vietnam, volumes 1-3 (Pham Hoang Ho, 1999-2003), Vietnam Timber Resources (Tran Hop, 2002), Economic Timber Trees in Vietnam (Tran Hop & Nguyen Boi Quynh, 2003), Kew Science. The species' scientific name was identified and regulated by Kew Science, World flora online. The composition of the plant species was classified according to the taxonomy of Brummitt (1992) in combination with the Melbourne International Nomenclature Law (Melbourne Code, 2012).

IVI = RD + RF + RBA (Mishra, 1968) (1)

$$D = \frac{Total\ number\ of\ individuals\ of\ t\ \ e\ species\ in\ all\ sample\ plots}{Total\ of\ sample\ plots} \quad (2)$$

$$RD(\%) = \frac{D\ of\ eac\ \ species}{Total\ of\ D\ of\ all\ species} x\ 100 \quad (3)$$

$$F(\%) = \frac{Number\ of\ sample\ plots\ wit\ \ species\ occurring}{Total\ number\ of\ study\ sample\ plots} x\ 100 \quad (4)$$

$$RF(\%) = \frac{F\%\ of\ eac\ \ species}{Total\ of\ F\%\ of\ all\ species} x\ 100 \quad (5)$$

$$\text{Basal area (BA)} = \pi \times (DBH/2)^2 \quad (6)$$

$$RBA(\%) = \frac{BA\ of\ eac\ \ species}{Total\ of\ BA\ of\ all\ species} x\ 100 \quad (7)$$

$$A(\%) = \frac{Total\ number\ of\ individuals\ in\ all\ sample\ plots}{Number\ of\ sample\ plots\ wit\ \ species\ appearing} x\ 100 \quad (8)$$

$$\text{(A/F) Spatial distribution pattern} = \frac{A(\%)}{F(\%)} \quad (9)$$

Threatened species have been identified by Decree 06/2019 of the Vietnamese Government, the Vietnam Red Data Book (2007), and the IUCN Red List (2021) (updated June 2021).

Importance Value Index (IVI) (Mishra, 1968): The index IVI of each species was determined by the formula (1). Density (D); Relative density (RD%); Frequency (F%); Relative frequency (RF%); Basal area (BA); and the relative basal area (RBA%) (Rastogi, 1999; Sharma, 2003; Pandey *et al.,* 2002) were calculated by the formula (2), (3), (4), (5), (6), (7), respectively. Abundance (A) and spatial distribution pattern (A/F) (Curtis and Mclntosh (1950) were determined by the following equations (8), and (9), respectively.

The Margalef index (d), Shannon–Weiner (H'), Simpson (Cd) (1949), Pielou (J') were calculated with the software PRIMER 6.1.6. The Shannon-Wiener index (H) was interpreted basis on the description by Fernando (1998): low (H' = 1 – 2.49), moderate (H' = 2.5 – 2.99), high (H' = 3 – 4).

The cluster analysis diagram, NMDS (Non-Metric Multidimensional Scaling), and PCA: (Principal Component Analysis) were used to analyze the relationship between species, plant communities, and forest states. The SPSS 23 software was used to compare the diversity indices between 3 states rich, medium, and poor forest.

3. RESULTS

3.1. Wood plant species component

3.1.1. Composition of woody species

A total of 1520 individual trees, 114 woody plant species, 89 genera of 41 families belonging to Magnoliophyta were identified in the Tan Phu forest, Dong Nai province.

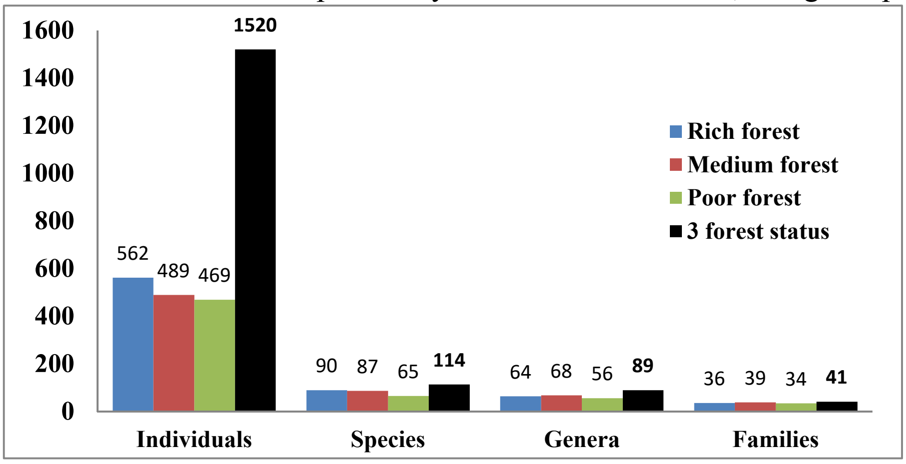

Figure 1. Species composition according to forest status

The richest families (≥ 5 species) had a total of 57 species (50% of the total species) including Euphorbiaceae with 11 species (9.65%) the richest; followed by Dipterocarpaceae and Rubiaceae with the same 9 species (the same 7.89%); Myrtaceae with 7 species (6.14%); Clusiaceae had 6 species (5.26%); while the remaining families were Malvaceae, Fabaceae, and Ebenaceae with the same 5 species (the same 4.39%). Thus, these plant families play an important role in the plant resources of the Tan Phu forest.

A total of 8 rich genera with 32 species (28.07% total species) were discovered. In which, *Syzygium* was the richest with 7 species (6.14%); followed by *Diospyros* with 5 species (4.39%); *Dipterocarpus* and *Garcinia* had the same 4 species (the same 3.51%); genera *Aporosa, Canthium, Cleistanthus,* and *Vitex* together had 3 species (the same 2.63%).

Most individual trees and species richness were found in the rich forests with 562 trees (36.97%) and 90 species (78.95%), followed by medium forests with 489 trees (32.17%) and 87 species (76.32%), to be found at least in poor forests with 469 trees (30.86%) and 65 species (57.02%) (Figure 1).

In the taxonomic of the genera and families, the medium forest was identified as the most diverse with 68 genera (76.40%) and 39 families (95.12%), followed by the rich forest with 64 genera (71.91%) and 36 families (87.80%), at least in the poor forest with only 56 genera (62.92%) and 34 families (82.93%) recorded (Figure 1). The abundance and diversity of taxa change depending on the state of the forest. This is the basis for proposed solutions for the preservation of woody plants in the study area.

3.1.2. Threatened species composition

Out of a total of 114 species recorded, 33 species (28.95%) were identified as threatened. Of which, 7 species were listed in the Vietnam Red Data Book (2007) (3 species at Endangered (EN) and 4 species at Vulnerable (VU)); 3 species in Prime Minister's Decree 06/2019 of the (*Dalbergia cochinchinensis, Sindora siamensis, Dalbergia oliveri* of group IIA); and 32 species listed in the IUCN (2021) (5 species at Endangered (EN), 8 species at Vulnerable (VU) and 19 species with Least Concern (LC)). A detailed analysis in each state showed that 26/33 species were found in rich and medium forests, while 19/33 species were explored in the poor forests.

3.2. Quantitative analysis of some woody plant diversity indices

3.2.1. Important Value Index (IVI)

Table 1 shows that the number of ecologically significant species and the ecologically dominant group of species in the states and the entire study area was quite similar (of 19 - 20 species and 4 - 5 species, respectively). The ecologically dominant species composition did not differ significantly between the states and all three states. Instead, the ecological role of each specific species had an ordinal reversal (the IVI value of each species was different in each state) in different forest states. In general, *Dipterocarpus dyeri, Irvingia malayana, Syzygium grande, Diospyros lancaefolia, Cratoxylum formosum, Lagerstroemia calyculata, Xerospermum noronhianum, Parinari annamensis* were the species that belonged to the ecologically dominant group of species and occur frequently in the investigated bocations. This observation was consistent with the research by Le Van Long *et al.* (2020), and reported by Nguyen Van Hop *et al.* (2020). Depending to space and time, they will form plant communities, in which the ecologically dominant group of species shows a high degree of similarity.

Table 1. IVI Index of species in forest states

No.	Species	Rich forest	Species	Medium forest	Species	Poor forest	Species	3 forest status
1	Dipdye	18.57	Syzgra	13.92	Lagcal	16.50	Syzgra	10.92
2	Irvmal	12.18	Diolan	12.13	Crapru	14.62	Irvmal	10.80
3	Hopodo	9.37	Xernor	10.57	Syzgra	14.45	Diolan	10.66
4	Lagcal	9.22	Lagcal	8.75	Diolan	12.18	Lagcal	10.51
5	Parann	8.15	Vitpub	8.59	Adicor	12.08	Dipdye	10.36
	5 species	*57.49*	*5 species*	*53.95*	*5 species*	*69.83*	*5 species*	*53.25*
	14 species	*83.62*	*15 species*	*93.96*	*15 species*	*113.00*	*14 species*	*86.58*
	***19** species*	***141.11***	***20** species*	***147.91***	***20** species*	***182.82***	***19** species*	***139.84***
	71 other species	***158.89***	***67 other species***	***152.09***	***45 other species***	***117.18***	***95 other species***	***160.16***
	Total	**300**	**Total**	**300**	**Total**	**300**	**Total**	**300**

Legend: Dipdye: Dipterocarpus dyeri; Irvmal: Irvingia malayana; Hopodo: Hopea odorata; Lagcal: Lagerstroemia calyculata; Parann: Parinari annamensis; Syzgra: Syzygium grande; Diolan: Diospyros lancaefolia; Xenor: Xerospermum noronhianum; Vitpub: Vitex pubescens; Crafor: Cratoxylum formosum; Adicor: Adina cordifolia;

3.2.2. Some indices of woody plants diversity

Figure 2 shows that species richness and the Margalef index were highest in a rich forest, followed by a medium forest and the lowest in a poor forest.

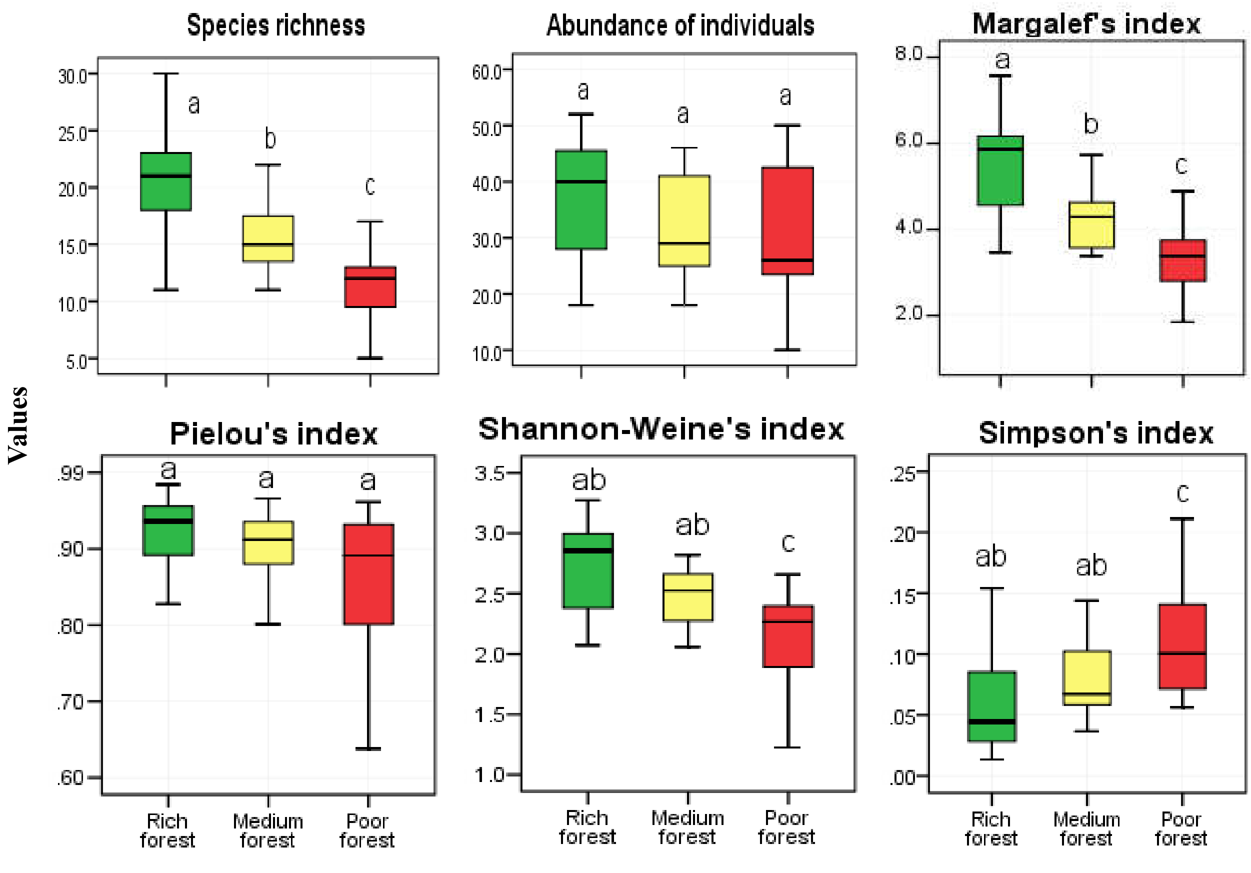

Figure 2. Distribution of the indicators of plant biodiversity in 3 forest states

(Legend: Different letters a, b, c stand for statistically significant (P < 0,05) differences in the Turkey-B criteria)

The Turkey-B analysis indicated that there was a statistically significant difference between the 3 states (P-value < 0.05). The species richness (S) and the Margalef index (d) therefore depend on status of the forest. For the abundance of individual trees and the Pielou index (J'), highest value was determined in a rich forest, followed by a medium forest and the lowest was measured in the poor forests. The comparision of these two indices showed that there was not a statistically significant difference (P-value > 0.05). The fregency of individual trees and the Pielou index (J') therefore did not depend on the forest status. In other words, these two indicators were similar in different forest states. Meanwhile, the highest diversity of the Shannon-Wiener (H') and Simpson (Cd) index was found in the rich forests, followed by medium forest and the lowest in poor forests. The average Shannon-Wiener (H') index of the 3 states was 2.42 ± 0.46. According to the Fernando (1998) classification scale, the variety of woody plants in the forest of Tan Phu was low. The (H') and (Cd) index showed statistically significant differences between rich with poor forests and between medium with poor forests (P-value < 0.05). However, there was not a significant difference between rich and medium forests. This showed that there was a similarity in diversity between rich and medium forest, while the diversity between rich with poor forest and medium with poor forests showed a significant difference. These results formed the scientific basis for proposing solutions for the management and preservation of plant diversity in the study areas.

3.2.3. Spatial distribution characteristics of the species (A/F)

The characteristics of the spatial distribution of species of each state and the entire region showed that the number of species distributed in stable sites was not significant (1 - 3 species, 1.15% - 4.6%): *Barringtonia pauciflora, Shorea roxburghii, Dipterocarpus dyeri, Cleistanthus indochinensis, Hopea odorata, Cratoxylum formosum*; from 4 to 16 species (6.90% - 24.62%) distributed in areas with unstable habitat conditions; while most of the species were common in the areas where inter-spcies competition was intense (47 - 80 species, 70.77% - 91.95%). In general, woody plants were distributed in unstable living conditions and where the relationship between the species was strict, the competition for nutrients space, light, etc.

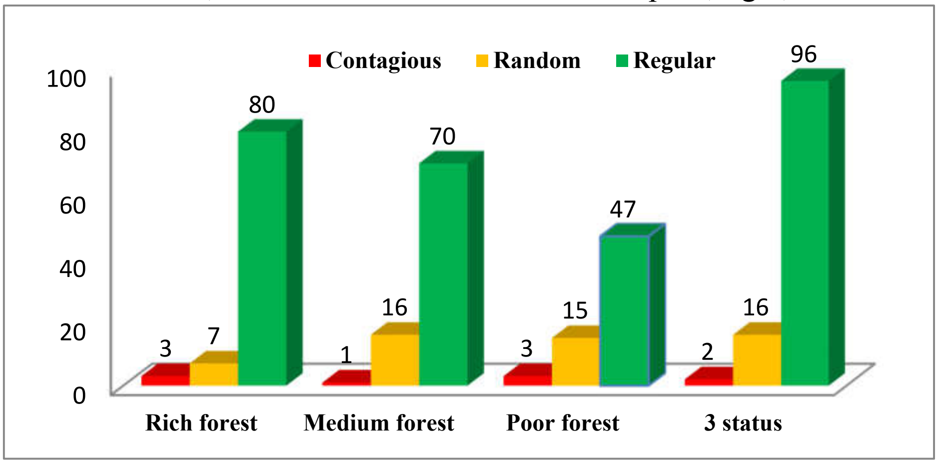

Figure 3. Spatial distribution characteristics of species in different states

This was explained by the selective harvesting that took place in the 80s and late 90s of the last century, with species of wood with economic value being the main objects of exploitation. This disrupts the species composition and the natural structure of the forest, which influences the growth and regeneration process of the forest.

3.3. Relationships between species, communities, and forest states

3.3.1. Relationship between species

The cluster diagram (Figure 4) showed the distribution of the species (species group) according to different levels of similarity. In 10%, divided into 13 groups, group 5 only had *Knema pierrei*, which was distributed independently, group 1 includes *Dalbergia cochinchinensis* and *Aporosa microstachia*, group 7 includes *Calophyllum calaba* var. *bracteatum* and *Syzygium cumini.*

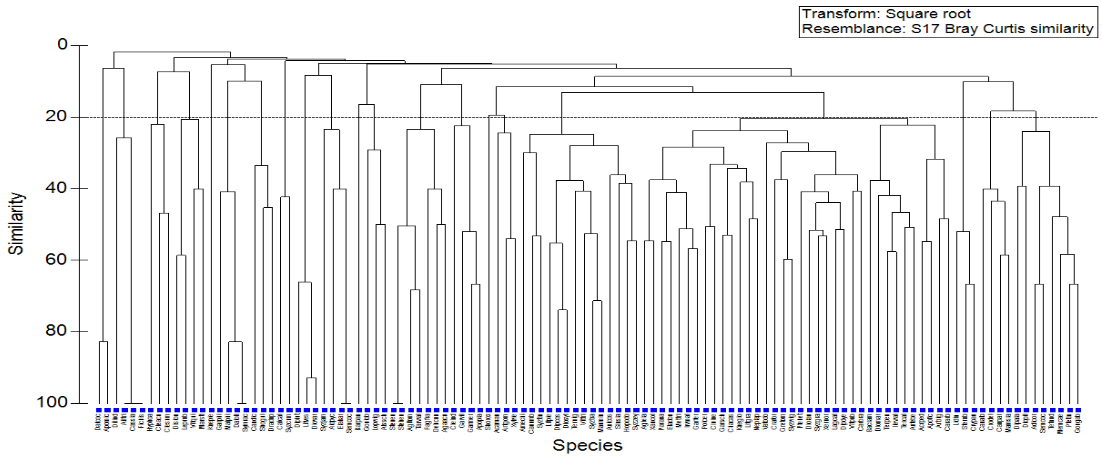

Figure 4. The relationship between the species is analyzed using a cluster diagram with different levels of similarity

In 20%, divided into 21 groups, in which groups 1, 11, and 15 each group had an independent species, with little dependence on the remaining species were *Knema pierrei,* *Shorea roxburghii,* and *Barringtonia pauciflora*, respectively. With 40%, 60%, 80% and 90% similarity, 54, 98, 111 and 113 groups were divided into respectively.

The results of the MDS analysis (Figure 5) showed that *Dalbergia oliveri, Dalbergia cochinchinensis, Knema pierrei, Aporosa microstachia* each species only occurs in one individual in communities 18, 44, 4, and 44, respectively. These were rare in the study area due to the very low number and frequency of occurrence. In addition, based on the threatened species composition identified in this study, we recommend the following ranking for conservation: *Dalbergia oliveri, Dalbergia cochinchinensis, Knema pierrei, and Aporosa microstachia*. This ensures that the number of species prioritized for conservation is minimized while meeting the forest owner's needs for human, material and financial resources.

The PCA analysis (Figure 7) showed that *Dipterocarpus dyeri, Barringtonia pauciflora, Cratoxylum formosum, Lagerstroemia calyculata, Pterospermum megalocarpum, Clistanthus indochinensis, Syzygium grande, Carallia brachiata, Diospyros lancaefolia* were the main plants; *Dipterocarpus dyeri, Barringtonia pauciflora* inverse relation to *Cleistanthus indochinensis, Syzygium grande, Carallia brachiata, and Diospyros lancaefolia*; while *Cratoxylum formosum* had close ties to *Pterospermum megalocarpum* and *Lagerstroemia calyculata*. This is an important basis for the selection of plant species for afforestation under similar ecological conditions.

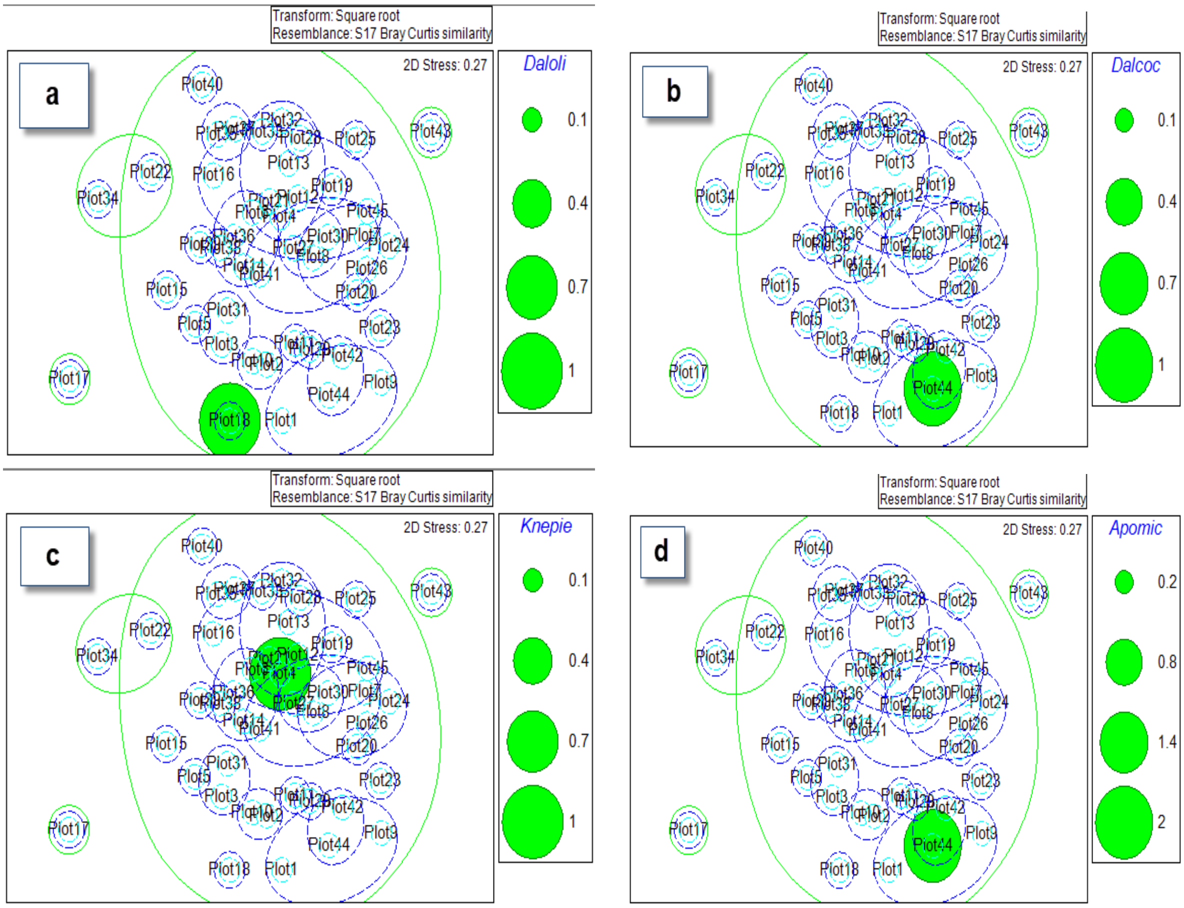

Figure 5. Species distribution: (a) *D. oliveri*, (b) *D. cochinchinensis*, (c) *K. pierrei*, (d) *A. microstachya* were analyzed using an MDS diagram

3.3.2. Relationships between plant communities

With 20% similarity, the plant communities were divided into 4 main groups and were affected by the forest status (Figure 6). Group 1 had only distributed community 17 in the medium forest. Group 2 includes communities 22 and 34, which are distributed in medium and poor forests.

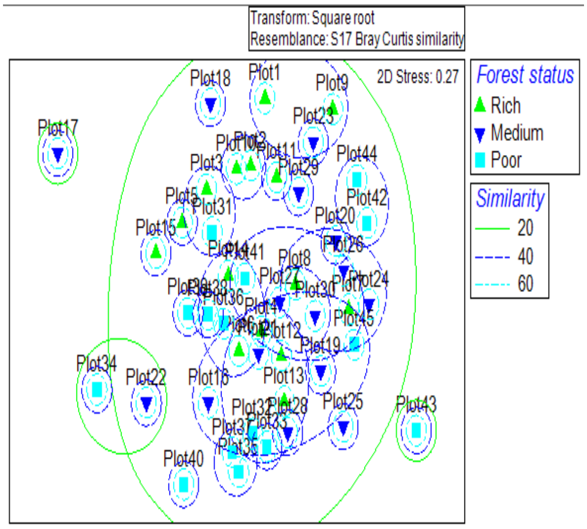

Figure 6. The relationship of plant communities was analyzed by MDS diagram

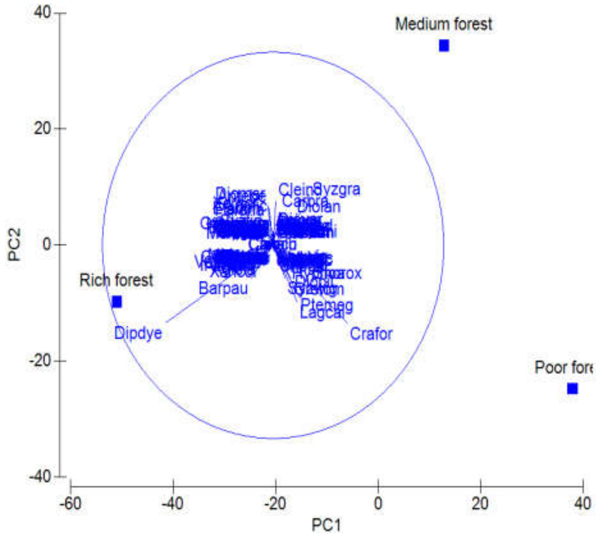

Figure 7. The composition of the main species was analyzed using a PCA diagram

Group 3 includes community 43 belong to a poor forest, while group 4 includes communities that could be spread across all 3 different forest states. At 40% and 60%, similarities were divided into 29 and 45 groups of communities, respectively.

The results of the analysis of the MDS diagram indecated that community conservation 43 should be a prioritized. Because at the lowest level of similarity (20%), this community was distributed alone and had no relationship to the other communities. Therefore, the adaptability to changes in environmental conditions is not high, and the sensitivity to the effects of the external environment is not hight. On the other hand, these communities are poor forests, which were characterized by species component, forest structure, unstable density, and in which competition between species often takes place harshly and often under the influence of unstable living conditions.

3.3.3. Relationships between forest states

The analysis of the cluster diagram (Figure 8) showed that, 70% similarity was divided into 2 groups (group 1: poor forest; group 2: medium and rich forest), so that poor forest is independently distributed and has little relationship to the rest of the state; meanwhile at 80% similarity it was divided into 3 groups (rich, medium, and poor). The Caswell index ranges from -0.32 to 1.06 in the stable range (-2 to 2), so it belongs to stable forests and was less influenced by humans. However, the comparison between the three states showed that rich forests were least affected, followed by medium and poor forests.

By analyzing the cluster and the Caswell index, poor forests need to be given priority and attention in management and conservation. Due to the low diversity of these communities, the unstable growth, impaired by human activities, woody vines, and overwhelming tree species thrive. The pruning method should therefore be given priority to reduce the competitive pressure on woody species and to create maximum space for the target tree species.

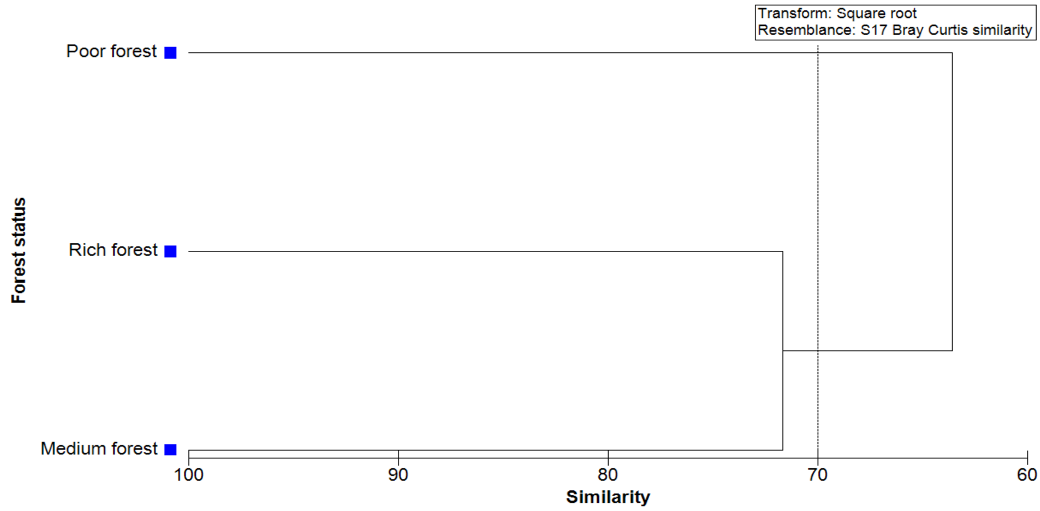

Figure 8. The relationship between the state of the forest was analyzed using a cluster diagram

3.3.4. Relationship between species count and sample plots count

The species accumulation curve analysis of 45 sample plots (2.25 ha) in 3 forest states showed that the number of species increases with sample plots. In rich forests, the cumulative number of species increased sharply (from plot 1 - 15), in medium forests the increase gradually decreased (from 16 - 30), and the lowest was recorded in poor forests. It was shown that the potential for species richness in the study area is still increasing. To fully identify the list of woody plants (diversity) of the Tan Phu forest, future studies will need to increase the sample size to greater than 45 sample plots (25 m × 20 m each plot).

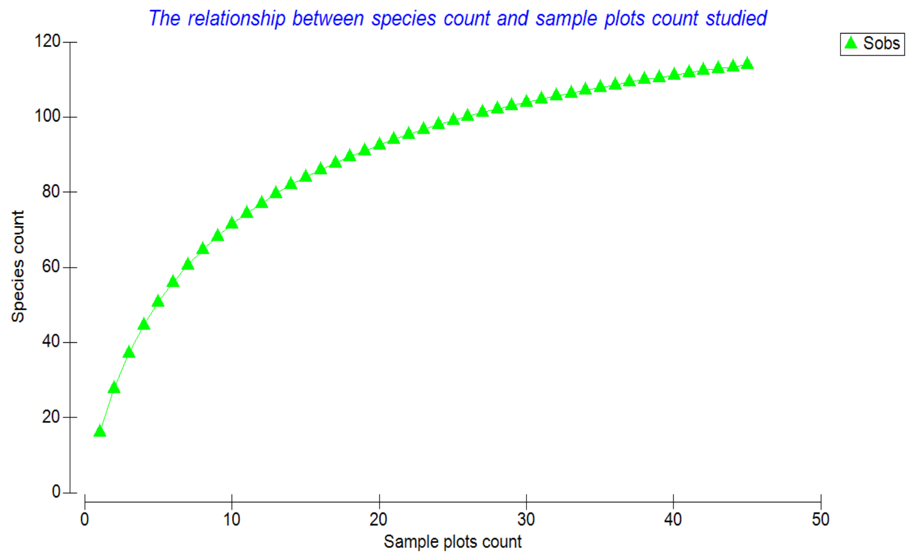

Figure 9. The relationship between sample plots count and species count was recorded in the study are

4. DISCUSSION

The species component in the present study is more diverse than in some previous studies. The report, which was carried out by Phan Minh Xuan (2012) in the Tan Phu forest recorded 71 species, 49 genera, and 36 families; meanwhile, 92 species of 40 families were recorded by Nguyen Van Hop *et al.* (2020) in the *Shorea roxburghii* community; Besides, Le Van Long *et al.* (2020) discovered 42-63 species, from 18 - 24 families in the communities of Dipterocarpaceae. However, the threatened species count was observed in this study was less than that reported by Nguyen Van Hop *et al.* (2020) (37 species) conducted in the *Shorea roxburghii* community. Through the study of several plant biodiversity indices, the present study identified low diversity. While Nguyen Van Hop *et al.* (2020) found moderate diversity in the *Shorea roxburghii* dominant community. This result could be described by the different spatial and topic scopes of these two studies.

By analyzing MDS, Vien Ngoc Nam *et al.* (2012) found that those plant communities that were independent and unrelated to the remaining communities that should be prioritized are taking protective measures. The MDS analysis was also carried out by Luu Ngoc Tram Anh *et al.* (2018) to identify the most suitable habitat for some true mangrove species in Con Trong, Ca Mau. In this report, too, based on Cluster analysis, researchers have selected species that were independently distributed and less dependent on the remaining species at the appropriate level of similarity in order to prioritize conservation. Meanwhile, the Caswell index has been used by Nguyen Thi Hien Luong & Vien Ngoc Nam (2010) to account for the plant communities that should be prioritized for conservation. Thus, the selection of species, communities, and types of vegetation for protection depends on their relationship in each ecological zone. Species, communities, and vegetation that are independently, individually, and with little or no relationship to other species, communities and vegetation distributed will be a prioritized in protecting biodiversity. In addition, nature conservation must also take into account species, communities, and states that are heavily affected by human activities. On the other hand, endangered, precious, and rare plant species, which are listed in the Government's Decree 06/2019 and in the Vietnam Red Data Book (2007), must also be taken into account. In practice, the selection of objects to be protected also depends on the financial, human, and physical conditions of the forest owner.

5. CONCLUSION

We recorded a total of 114 species of woody plants of 89 genera belonging to 41 families in the Tan Phu forest. Of which, 33 species (28.95%) were identified as threatened.

The number of ecologically significant species and the ecologically dominant group of species among the forest states were very similar. *Diptercarpus dyeri, Irvingia malayana, Syzygium grande, Diospyros lancaefolia, Cratoxylum formosum, Lagerstroemia calyculata, Xerospermum noronhianum, Parinari anamensis* were the ecologically dominant group in all 3 states. However, the role of each species changed in each state.

The species richness and Margalef (d); Shannon-Weiner (H') and Simpson (Cd) depends on forest status; while tree abundance and the Pielou index (J') were not influenced by the forest status. The diversity of the woody plants in the Tan Phu forest was classified as low.

Most of the woody plants were distributed in unstable habitat conditions, where the relationship between species was severe and for space for nutrients, light, etc.

At the species level, *Dalbergia oliveri, Dalbergia cochinchinensis, Knema pierrei, Aporosa microstachia*; and at the community level, community 43 has been recommended as a conservation priority; while at the status level, poor forests were recommended as a priority for conservation.

As the number of sample plots increases, the number of species increases and tends to be unstable. To ensure full identification of the list of woody plant species in the study area, future studies must therefore increase the number of samples to greater than 45 plots.

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ĐA DẠNG THỰC VẬT THÂN GỖ TRONG RỪNG KÍN THƯỜNG XANH MƯA ẨM NHIỆT ĐỚI TẠI RỪNG TÂN PHÚ, TỈNH ĐỒNG NAI

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TÓM TẮT

Đa dạng thực vật giữ vai trò quan trọng trong việc duy trì các chức năng phòng hộ và lợi ích của rừng. Nghiên cứu này nhằm xác định tính đa dạng của thực vật thân gỗ làm cơ sở đề xuất các giải pháp bảo tồn tài nguyên thực vật tại rừng Tân Phú, tỉnh Đồng Nai. Tổng số 45 ô mẫu được chia đều ở 3 trạng thái rừng, bên cạnh đó phần mềm Primer 6.1.6, SPSS 23 cũng được sử dụng để phân tích dữ liệu. Nghiên cứu cho thấy, tổng số 114 loài thực vật thân gỗ thuộc 89 chi thuộc 41 họ đã được ghi nhận. Có 33 loài (28,95%) được xác định là bị đe dọa. Trong số này, có 7 loài nằm trong Sách Đỏ Việt Nam (2007), 3 loài trong Nghị định 06/2019 của Chính phủ và 32 loài trong Sách Đỏ IUCN (2021). Các loài và nhóm loài ưu thế sinh thái lần lượt dao động từ 19 đến 20 loài và từ 4 đến 5 loài. Chỉ số đa dạng Margalef (d), Pielou (J'), Shannon-Weiner (H') và Simpson (Cd) đã được phân tích, cho thấy mức độ đa dạng của thực vật thân gỗ ở rừng Tân Phú là thấp. Hầu hết các loài được phân tích (70,77 - 91,95%) có dạng phân bố liên tục. Các loài *Dalbergia cochinchinensis, Aporosa microstachia, Dalbergia oliveri, Knema pierei*; quần xã 17 và 43; và trạng thái rừng nghèo được xác định phân bố độc lập và không có mối quan hệ với các loài, quần xã và các trạng thái rừng khác. Kích thước ô mẫu cần thiết để xây dựng danh lục các loài thân gỗ phải lớn hơn 45 ô mẫu. Những kết quả nghiên cứu này là cơ sở khoa học đáng tin cậy nhằm định hướng chiến lược quản lý và bảo tồn tài nguyên rừng, góp phần nâng cao lợi ích và hiệu quả chức năng phòng hộ của rừng tại khu vực nghiên cứu.

Từ khóa: đa dạng, MDS, sơ đồ cluster, Tân Phú, thực vật thân gỗ.

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