Diversity and ecological role of *Dipterocarpus obtusifolius* Teijsm. ex Miq. in Nui Cau - Dau Tieng protection forest, Binh Duong province

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Đa dạng và vai trò sinh thái của Dầu trà beng (*Dipterocarpus obtusifolius* Teijsm. ex Miq.) tại Rừng phòng hộ Núi Cậu - Dầu Tiếng, tỉnh Bình Dương

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ABSTRACT
Studying the diversity and ecological role of dominant species provides an important foundation for understanding the influence of dominant species on the diversity and biomass production capacity of plant communities. This study was conducted at the Nui Cau - Dau Tieng Protection Forest Management Board, Binh Duong province, to understand the diversity and ecological role of Dipterocarpus obtusifolius Teijsm. ex Mig. in the ecosystem forests. A total of 19 plots, each 0.1 ha in size (50 m x 20 m), were used for data collection. Trees with a diameter at breast height (dbh) ≥ 6 cm were recorded, including species name, number of individuals, dbh, and overall height. The study employed importance value index analysis (IVI%) and aboveground biomass (AGB) to assess the ecological role of dominant species. Findings revealed that: (1) Communities with dominant species had low species richness and fluctuating diversity levels, (2) The ecological role of dominant species varied across forest states, decreasing from very poor > poor > medium forests, and (3) Increasing IVI% and AGB% of dominant species influenced woody species structure and biomass output in the plant community. This study offers valuable insights to enhance forest management and quality in the area.

Keywords:
Biomass, Dipterocarpaceae, dominant species, ecological function, IVI index.

TÓM TẮT
Nghiên cứu đa dạng và vai trò sinh thái của loài ưu thế mang lại những cơ sở quan trọng để hiểu được ảnh hưởng của các loài ưu thế đến tính tính đa dạng và khả năng sản xuất sinh khối của quần xã thực vật. Nghiên cứu này được thực hiện tại Ban Quản lý rừng phòng hộ Núi Cậu – Dầu Tiếng, tỉnh Bình Dương, nhằm tìm hiểu tính đa dạng và vai trò sinh thái của loài Dầu trà beng (Dipterocarpus obtusifolius Teijsm. ex Mig.) trong các hệ sinh thái rừng. Tổng số 19 ô nghiên cứu đã được thiết lập để thu thập dữ liệu, kích thước mỗi ô 0,1 ha (50 m × 20 m). Tất cả các cây gỗ có đường kính ngang ngực (dbh) ≥ 6 cm trong ô mẫu đều được thu thập và xác định các thông tin (tên loài, số lượng cá thể, đường kính ngang ngực, chiều cao). Hai phương pháp nghiên cứu là phân tích chỉ số giá trị quan trọng (IVI%) và sinh khối trên mặt đất (AGB) được sử dụng để xác định vai trò sinh thái của loài ưu thế. Kết quả nghiên cứu cho thấy: (1) Trong các quần xã có loài ưu thế, độ giàu loài thấp và tính đa dạng biến động từ rất thấp đến thấp, (2) vai trò sinh thái của loài ưu thế thay đổi

***Từ khóa**:*
Chức năng sinh thái, chỉ số IVI, họ Dầu, loài ưu thế, sinh khối.

theo trạng thái, giảm từ rừng nghèo kiệt > nghèo > trung bình, (3) khi chỉ số IVI% và tỷ lệ AGB% của loài ưu thế tăng, chúng sẽ quyết định kết cấu loài cây gỗ và năng suất sinh khối của quần xã thực vật. Nghiên cứu này cung cấp dữ liệu tin cậy giúp quản lý và cải thiện chất lượng rừng ở khu vực nghiên cứu.

1. INTRODUCTION

Dipterocarpus obtusifolius Teijsm. ex Miq., belonging to the Dipterocarpus genus of Dipterocarpaceae, is native to Vietnam, Laos, Cambodia, Myanmar, Thailand, and Peninsula Malaysia (Perlis) [1]. It is a tree that primarily grows in the seasonally dry tropical biome. In Vietnam, this species is naturally found mainly in Gia Lai, Kon Tum, Dak Lak, Lam Dong, Binh Phuoc, and Tay Ninh in sparse Dipterocarpa forests. The wood of this species is generally hard, heavy, and commonly used in construction projects, bridge building, and household appliance manufacturing [2].

There are various indicators to assess the ecological role of a population, with IVI (%) being a comprehensive index that best re ects the ecological role in the structure of woody plant species [3]. Previous studies have used the IVI% index to evaluate the function of dominant populations and communities by considering intermediate indices such as density of individuals, basal area, and stem volume [3, 4]. Despites, the biomass of trees is also an important indicator of their direct ecological role, as forest trees can convert biomass to in uence and regulate the climate. However, this indicator has not been used to assess the ecological role of dominant species in populations, communities, and ecosystems.

Forest resources in the Nui Cau-Dau Tieng Protection Forest Management Board in Binh Duong province play a vital role in biodiversity conservation, climate regulation, and providing water for Dau Tieng Lake, which supplies domestic water and irrigation for the Southeast region. Additionally, it is a well-known ecological and spiritual tourism spot in the Southeast, boasting a rich variety of ora with 502 identi ed plant species [5]. Among these, *D. obtusifolius* is found, along with species like *A. roxburghii, A. costata, D. intricatus* from the Dipterocarpaceae family, as well as deciduous species like *C. formosum, I. malayana, P. anamensis*, contributing to the formation of deciduous and semi-deciduous forests.

However, data on the diversity and ecology of the dominant species has not been thoroughly examined as a basis for e cient forest resource management. This study aims to address two main questions: (i) diversity, and (ii) ecological signi cance of *D. obtusifolius* in the research area. The ndings obtained provide a reliable scienti c foundation for the e ective management, conservation, and enhancement of forest resources.

2.2. RESEARCH METHODS

2.2.1. Study site

The research was conducted from August to September 2022 at the Nui Cau Dau Tieng Protection Forest Management Board, Binh Duong province (Fig. 1). The study area was featured by rocky terrain, low hills, high slopes, and altitudes ranging from 20 m to 280 m above sea level. The tropical monsoon climate prevalent in the area included a rainy season from May to November and a dry season from December to April of the following year. The average annual rainfall was 1900-2000 mm, the average annual temperature was 27°C - 28°C. The combination of topography, geographical latitude, soil, hydrology, and the prevalence of tree species in the Dipterocarpaceae family (*D. obtusifolius, A. roxburghii, A. costata, D. alatus, P. siamensis*) led to the development of various forest types such as bamboo forests, mixed bamboo forests, shrublands, deciduous forests, semi-deciduous forests, and evergreen forests on rocky and dirt mountains [5].

2.2.2. Field survey

A total of 19 plots (50 m x 20 m) were established in 3 forest states: medium, poor, and very poor. For each plot, information on tree species, total number of individuals, diameter at breast height (dbh), and overall height (Hvn) was gathered. Trees with a diameter exceeding 6 cm were taken into account for dbh.

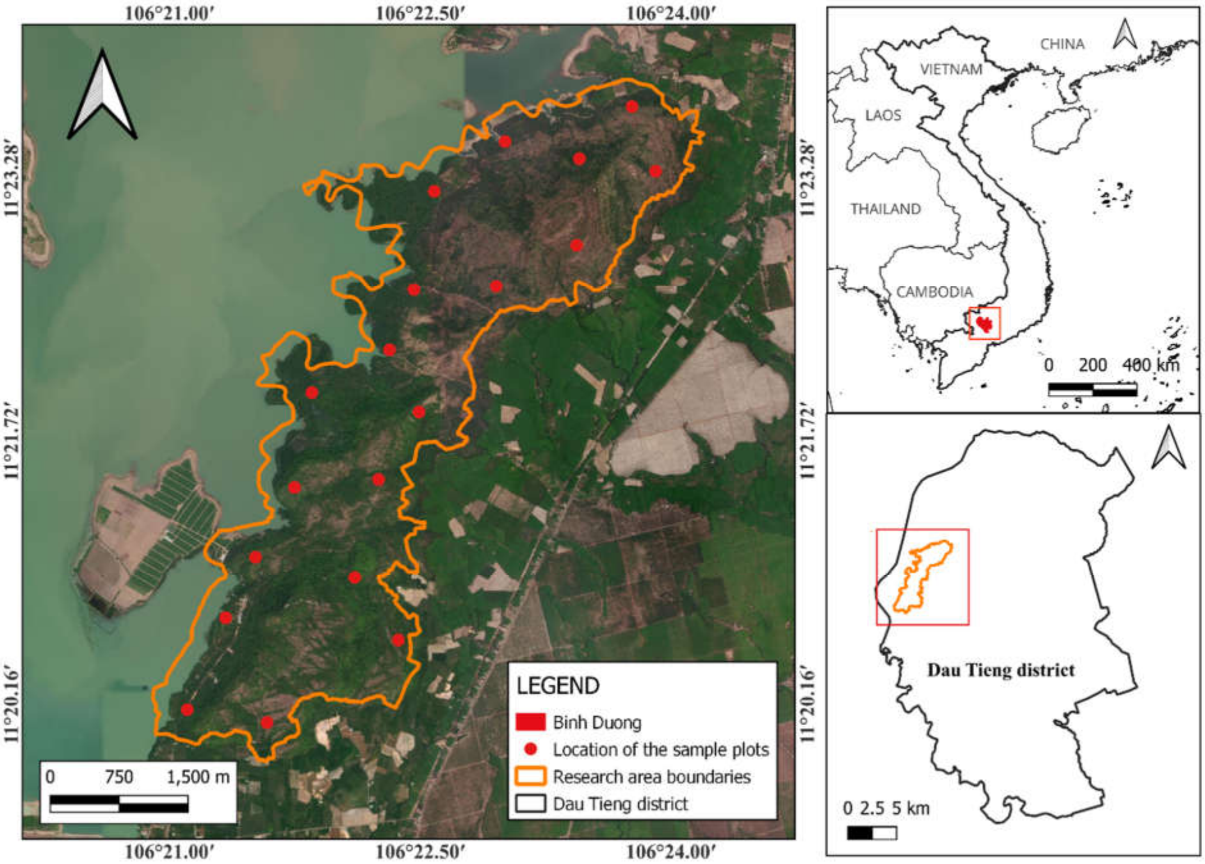

Figure 1. Boundaries and locations of the study plots

2.2.3. Data analysis

In each sample plot, the stem volume (m^3/ha) was calculated and then the investigation plots were classi ed into forest states. Which, medium forest: 100 < volume ≤ 200 (m^3/ha); poor forest: 50 < volume ≤ 100 (m^3/ha); and very poor forest: 10 < volume ≤ 50 (m^3/ha) [6]. The species name was identi ed by the technique of comparative morphology. The documents were applied to identify plant species: An Illustrated Flora of Vietnam, volumes 1-3 [7], Vietnam Timber Resources [2]. Scienti c names of species and plant classi cation were based on POWO [1]. The composition of endangered, precious, and rare plant species was identi ed by the Vietnam Red Data Book (2007) [8] and Decree 84/2021 of the Vietnamese Government [9].

The importance Value Index (IVI) was determined by Trung TV (1999) [10]:

$$IVI = (N\% + G\% + V\%)/3$$

where,

IVI: Importance Value Index;

N%, G%, and V% are density, basal area, and trunk volume, respectively.

$$V = G*H*F,$$

where,

F = 0.45. Species dominant and co-dominant were determined when IVI index ≥ 4% [3, 4].

A similarity index (SI) was determined by the formula of Sorensen (1948):

$$SI = 2c/(a + b)*100$$

where,

a: the number of species in state i;

b: the number of species in state j;

c: the number of similar species in states i and j;

(a + b): the overall number of species in state i and j.

Simpson (D), Shannon (H'), Evenness (J'), and Margalef (d) index were calculated by respectively.

$$D = \Sigma^{S}_{i=1}(ni/N)^2 = \Sigma^{S}_{i=1}p_i^2,\ H' = \sum_{i=l}^{s} \text{Pi} \quad \ln(\frac{\text{ni}}{\text{N}})\ ,\ J' = H'/Hmax = (H'/\ln(N)),\ \text{and}\ d = \frac{s-1}{\log N},$$

where,

ni: Number of individuals of species i;

N: Total number of individuals in the plot;

d: Margalef diversity index;

s: a total of species in the plot. Diversity level (H') was classi ed into very low (H'<1), low (2>H'≥1), moderate (3>H'≥2), high (4>H'≥3), and extremely high (H'≥4) [11].

Tree biomass was quanti ed using the following allometric equation: exp (-2.134 + 2.530 x ln(dbh) with DHB = 5-148 cm, n = 170 trees, R^2 = 0.97 [12]. For the biomass density, the total biomass per plot was multiplied by 10,000 m^2 divided by the plot size in square meters which was the data from 0.1 ha. Where, dbh = diameter breast height expressed in centimeters; Tree data were converted into tree biomass per module area (ha^{-1}).

Data were arranged and processed through Excel spreadsheet tool, and then they were analyzed by the R version 4.2.2.

3. RESULT

3.1. Diversity of woody plants

3.1.1. Species component

A total of 45 woody plant species were identi ed in the *D. obtusifolius* community. Among these, 34 species were found in poor forests, 22 species in medium forests, and 18 species in very poor forests (Fig. 2a). Of note, three species displayed the highest abundance of individuals (> 100 trees): *D. obtusifolius* with 730 trees, *C. formosum* with 317 trees, and *A. roxburghii* with 111 trees (Fig. 2b).

Sindora siamensis (EN), *Xylopia pierrei* (VU), and *Gluta laccifera* (VU) were recognized as endangered, precious, and rare species listed in the Vietnam Red Data Book (2007). Notably, only *Sindora siamensis* falls under group IIA of Decree 84/2021 by the Vietnam Government.

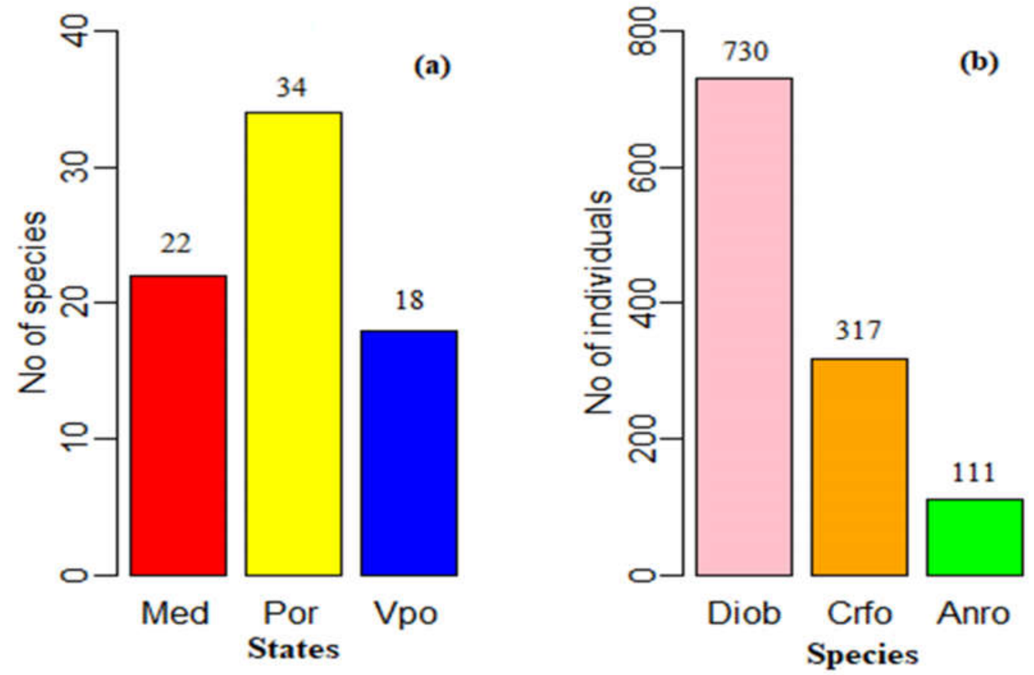

Figure 2. Species composition and tree abundance of species

Med: Medium forest, Por: Poor forest, Vpo: Very poor forest; Diob: Dipterocarpus obtusifolius, Crfo: Cratoxylum formosum, Anro: Anthoshorea roxburghii

3.1.2. Some plant diversity indices

The study results indicated that there were signi cant variations in individual tree abundance in di erent forest states (P_value < 0.01). Meanwhile, there were no statistically considerable di erences in species richness, Simpson, Shannon, Evenness, and Margalef index (P_value > 0.05). The species richness, Simpson and Margalef index reduced from poor > medium > very poor forest. Individual tree abundance decreased from medium > poor > very poor forest. The Shannon index reduced from very poor > medium > poor forest. The Evenness index decreased from very poor > poor > medium forest (Fig. 3).

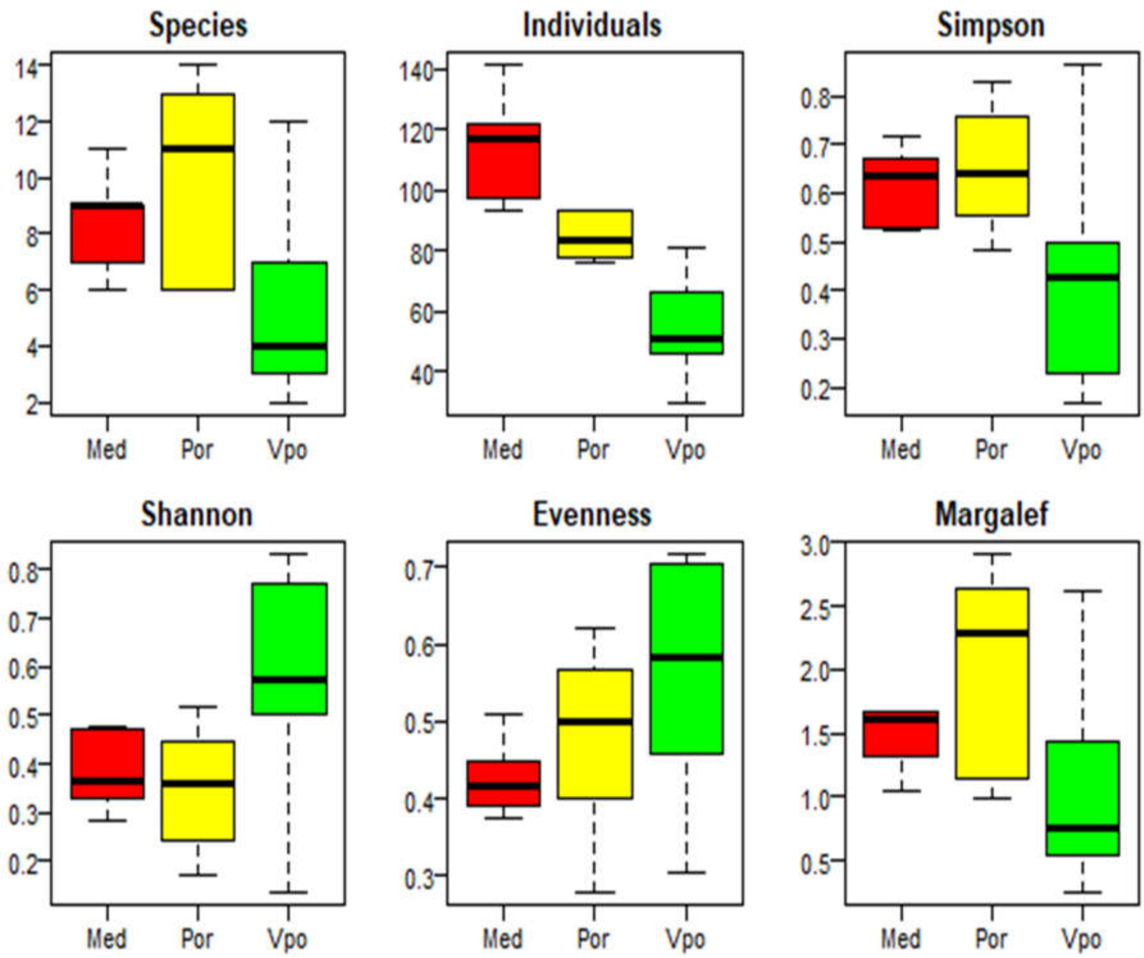

Figure 3. Several of the feathers of the diversity index

Med: Medium forest, Por: Poor forest, Vpo: Very poor forest

The analysis showed a high resemblance index SI ranging from 0.61 to 0.64. The species composition di ered signi cantly between medium and poor forests, with the lowest similarity (SI = 0.61). Conversely, the similarity index SI was higher between medium and very poor forests, and between poor and very poor forests (0.63-0.64). Similar conclusions were drawn regarding variations in species composition among states' forests when assessed using the SI index in similarity analysis. According to the Bray-Curtis index, forest states could be divided into two groups with a dissimilarity of 73.47%. Group 1 consisted of poor forests, while Group 2 comprised medium and very poor forests (Fig. 4).

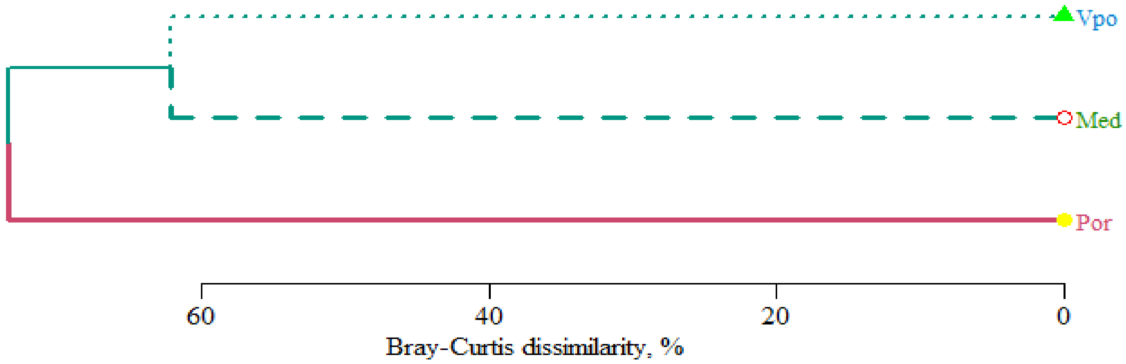

Figure 4. Di erences between states' forests as analyzed by the Bray-Curtis index

Med: Medium forest, Por: Poor forest, Vpo: Very poor forest. Three forest states were observed to di er signi cantly, with a dissimilarity of 73.47%. Group 1 was poor forests; Group 2 included medium and very poor forests

3.2. The ecological role of the *D. obtusifolius*

3.2.1. Ecological role of D. obtusifolius through IVI% index

The study results demonstrated no signi cant variation in the number and composition of dominant and co-dominant species among di erent forest states. *D. obtusifolius* and *C. formosum* were identi ed as ecologically dominant species in medium and poor forests, with *D. obtusifolius* being the dominant species in very poor forests. Despite poor forests having more species, the IVI% index of the dominant species group was lower compared to medium and poor forests.

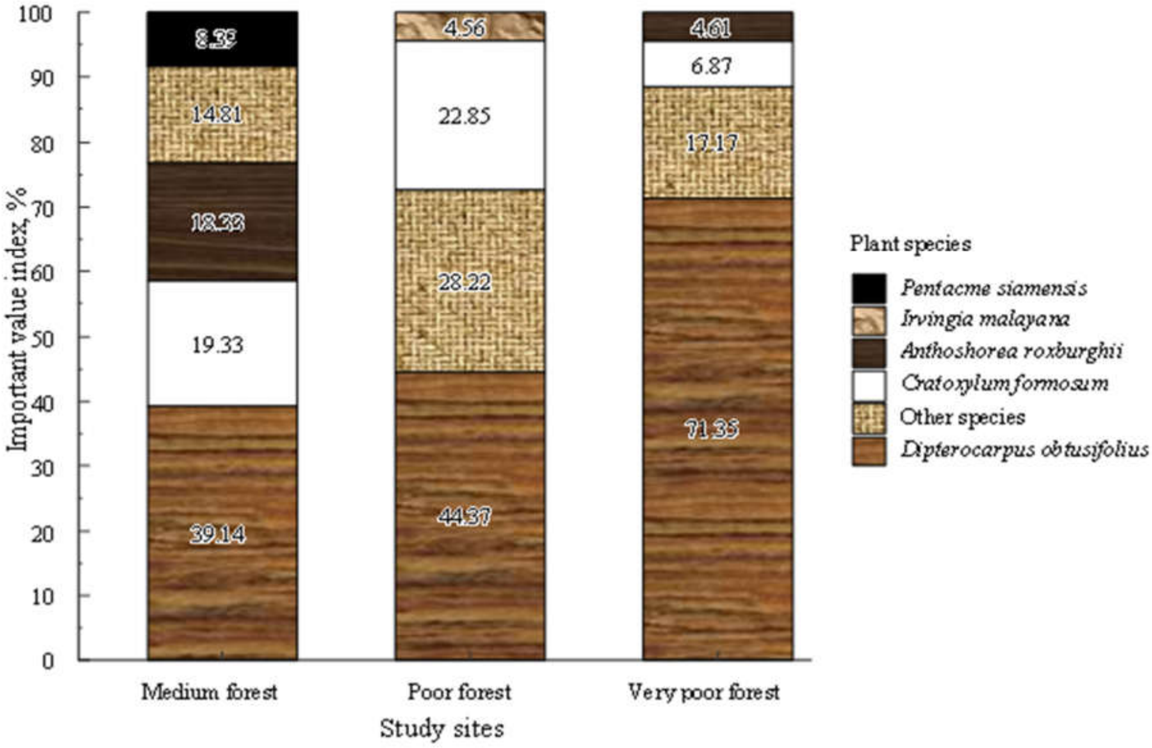

Figure 5. Ecological role of *D. obtusifolius* in the forest states

Speci cally, the species component reduced from poor (34 species) > medium (23 species) > very poor forests (18 species). Three ecologically signi cant species (IVI > 4%) were observed in poor and very poor forests, and 4 species in medium forests. In poor forest, *D.*

obtusifolius, C. formosum, and *I. malayana* were identi ed (Table 2); *D. obtusifolius, C. formosum,* and *A. roxburghii* in the very poor forest. Additionally, *D. obtusifolius, C. formosum, A. roxburghii,* and *P. siamensis* were found in medium forest (Fig. 5).

This study revealed that *D. obtusifolius* played a crucial ecological role in all forest conditions. However, its speci c role varied across di erent forest states in terms of IVI% di erence, although this variation was not statistically signi cant. Notably, *D. obtusifolius* emerged as the dominant species ecologically (IVI% > 50%) in extremely poor forests, whereas in poor and medium forests, it functioned as a co-dominant species (Fig. 5).

IVI% index of *D. obtusifolius* between states reduced from very poor > poor > medium forests (Fig. 7a, 7b, 7c). Therefore, the ecological of *D. obtusifolius* decreases from very poor > poor > medium forest.

3.2.2. The ecological role of D. obtusifolius through their ability to accumulate biomass

Above-ground biomass (AGB) of forest states has signi cant discrepancies (P_value < 0.01). Speci cally, aboveground biomass reduced from medium > poor > very poor forest (Fig. 6a).

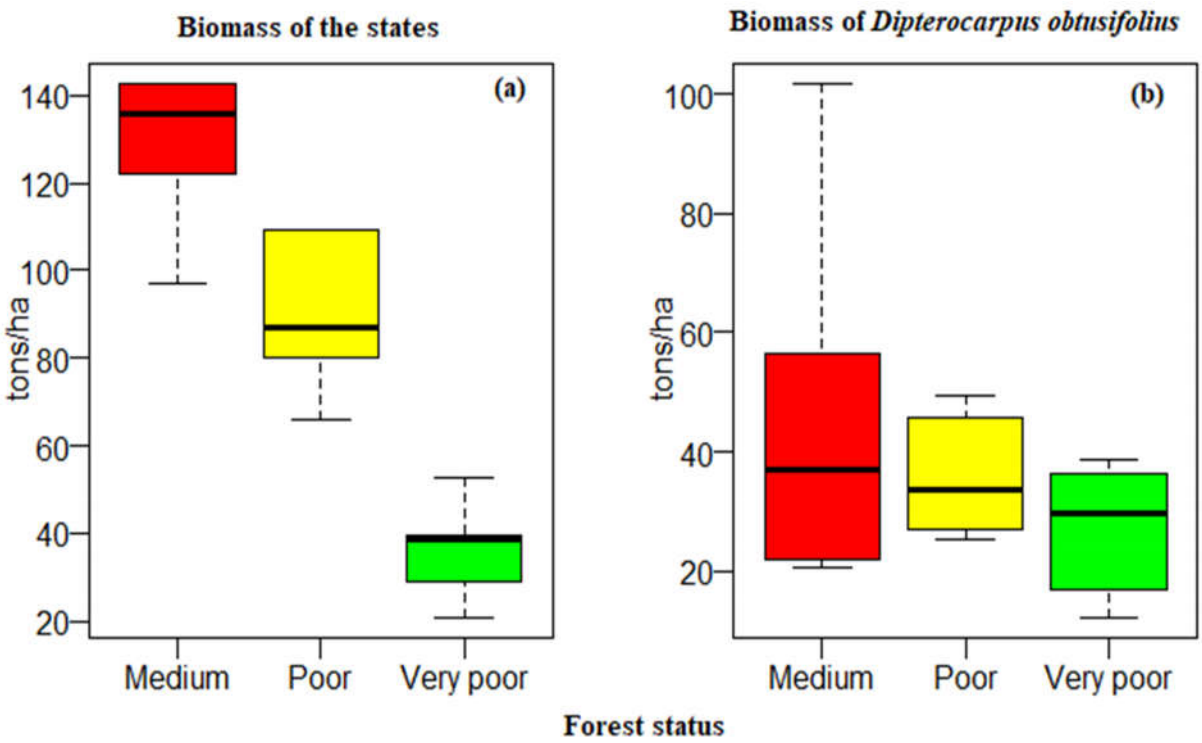

Figure 6. Biomass of the states and *D. obtusifolius*

The aboveground biomass of *D. obtusifolius* in di erent forest states was di erent, but this di erence was not statistically signi cant (P_value > 0.05), which decreased from the medium > poor > very poor forest (Fig 6b). So, the ecological role of *D. obtusifolius* in forest states decreased from medium > poor > very poor forest.

Comparing the biomass percentage of *D. obtusifolius* between states revealed a descending trend from very poor (75.46%) > poor (42.23%) > medium forest (34.49%) (Fig. 7d, 7e, 7f). The analysis indicated a decline in the biomass contribution of *D. obtusifolius* relative to other species across states, transitioning from very poor > poor > medium forest.

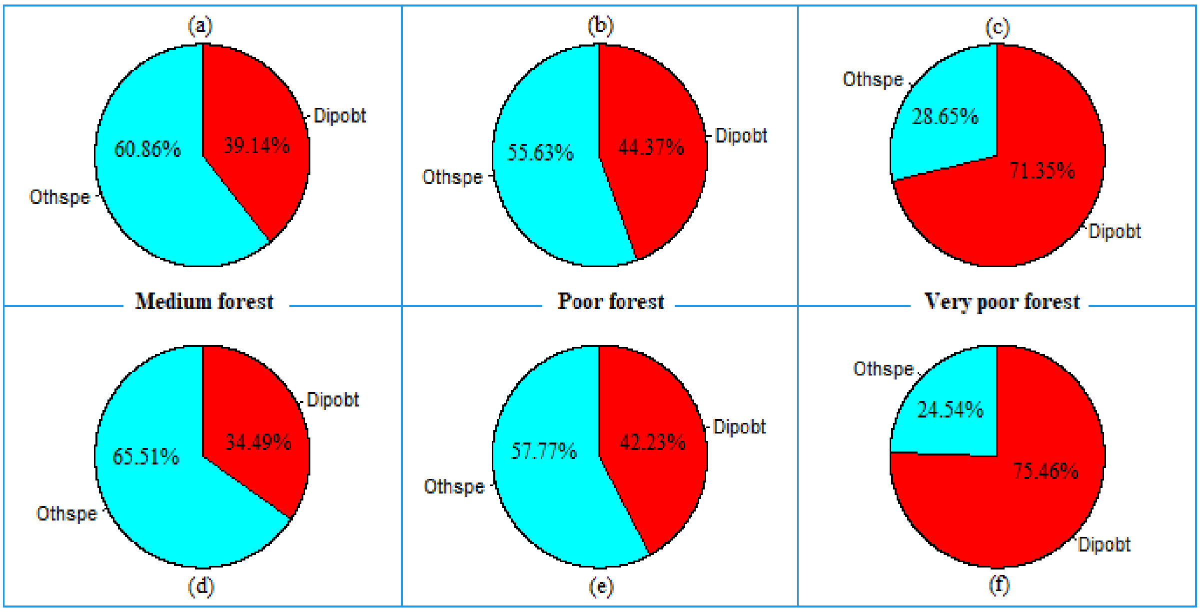

Figure 7. Comparison of IVI% and %AGB of *D. obtusifolius* in the forest states

Red color was Dipobt = Dipterocarpus obtusifolius, cyan color was Othspe = Other species

4. DISCUSSION

(1) Plant diversity

This study discovered a total of 45 tree species. Comparison with some dominant forests of Dipterocarpaceae in the Southeast showed that it was comparable to the dominant forest of *D. chartaceus* (45 species) in Binh Chau-Phuoc Buu Nature Reserve [13]. However, it was lower than the dominant forest *A. roxburghii* in Tan Phu Forest (92 species) [4]; *D. dyeri* (53 species), *D. alatus* (63 species), *A. costata* (55 species), *H. odorata* (60 species) [3]; 112 species in dominant forest of Dipterocarpaceae [14]. A Report on medium forests in Dong Nai Cultural Nature Reserve also recorded higher species richness (49 species), and 101 species [15].

This study illustrated that tree species diversity varies from very low to low (0.89±0.63-1.49±0.14), while the dominant forest of *D. chartaceus* in Binh Chau Phuoc Nature Reserve Buu spans from low to moderate (1.66 to 2.79) [13]. In the closed evergreen forest of the Dong Nai Cultural Nature Reserve, diversity was found to be higher than in the current research. The reports indicated that medium and rich forests con rm diversity at a moderate level (H'=2.41) [16], another report in medium forests also proves the diversity at the moderate level (H'= 2.36±0.25) [17]. Research in Dipterocarpaceae dominant forests in Tan Phu Forest shows higher diversity than the ongoing study. Speci cally, the *A. roxburghii* dominant species diversity varies from moderate to high (H'=2.87-3.05) [18]. A survey of the *D. dyeri, D. alatus, H. odorata, A. roxburghii,* and *A. costata* dominant communities demonstrated moderate to high diversity (H' = 2.52 - 3.23) [19]. Meanwhile, the overall diversity for the three forest states was determined to be at a moderate level (H' = 2.42±0.46) [14]

Variations in species component and Shannon diversity index may be due to dominant species and species groups. Dominant species can have an impact on ecosystems by decreasing local plant biodiversity [20]. On one hand, di erent species composition and dominant species groups can also a ect species richness. On the other hand, the method of selecting sample plots and site conditions can also impact species richness and the Shannon index.

(2) Ecological role

In this study, the IVI% index showed that, apart from *D. obtusifolius* (IVI=39.14%-71.35%), two other plant species also have a notable ecological impact: *C. formosum* (medium forest, 19.33% and poor forest, 22.85%), *A. roxburghii* (medium forest, 18.33%). Biomass productivity was mainly attributed to a few dominant species, with *C. formosum* (medium forest, 31.16% and poor forest, 13.05%), *A. roxburghii* (medium forest, 31.16%) in addition to *D. obtusifolius* (AGB = 34.49%-75.46%). Among the dominant and co-dominant species, *D. obtusifolius* acts as the ecologically dominant species in very poor forests (IVI = 71.35% and AGB = 75.46%). In the other two forest types, the ecological dynamics were signi cantly in uenced by two co-dominant species: *C. formosum* (medium and poor forest) and *A. roxburghii* (medium forest).

Studies conducted in Tan Phu forest have shown the signi cant ecological importance of *A. roxburghii* across di erent forest states, with its prominence increasing from poor (IVI = 21.8%) to medium (IVI = 26.8%) and rich forest (IVI = 29.2%) [4]. Additionally, research has highlighted the essential role of Dipterocarpaceae not only in terms of conservation and economic value but also in environmental and ecological aspects [3]. Which, Dipterocarpaceae emerges as a key player in various communities (IVI = 37.4%-59.5%), with dominant and co-dominant species ranging from 4 to 7 species. Moreover, species like *D. dyeri, D. alatus, H. odorata, S. roxburghii,* and *A. costata* have been identi ed as ecologically dominant within these communities (IVI = 26.3%-33.0%) [3].

The study revealed signi cant variations in biomass production among dominant forest states of *D. obtusifolius*. These ranged from medium forest (180±125.56 tons/ha) to very poor forest (35.52±10.45 tons/ha). This nding contrasts with dominant Dipterocarpaceae in Tan Phu Forest, Dong Nai, such as *A. roxburghii* (106.20-282.63 tons/ha) [18], *D. dyeri (349.22 tons/ha), D. alatus* (301.22 tons/ha), *H. odorata* (233.68 tons/ha), *A. roxburghii* (217.78 tons/ha), *and A. costata* (236.76 tons/ha) [19]. Notably, the *D. chartaceus* dominant community in Binh Chau-Phuoc Buu Nature Reserve exhibited lower biomass levels compared to this study (60.73-162.75 tons/ha) [13]. Additionally, the contribution of *D. chartaceus* to the total biomass was signi cantly less than that of *D. obtusifolius* in this investigation.

Ecosystem functioning is in uenced by the behavior of dominant species [21]. Productivity is typically associated with the biomass of a small number of dominant plant species [22]. Numerous studies have shown that ecosystem processes and productivity [23] are mainly driven by the functional characteristics of dominant plants rather than species diversity [21]. Dominant species tend to have better access to light, water, and nutrients in the soil. Moreover, they often demonstrate stronger competitive abilities [24] and can exert more pressure on other species. Conversely, dominant species may reduce species richness by outcompeting other species through interspeci c competition [25].

The presence of a dominant species can enhance ecosystem productivity as it e ciently utilizes ecological resources compared to other species [26]. However, if a few dominant species perform most ecosystem functions, there might be a negative relationship between ecosystem productivity and species diversity [27]. Dominant species, though few in number, play a crucial role in ecosystem functioning but are susceptible to external disruptions due to their high abundance, leading to reduced plant diversity. Therefore, the loss of dominant species, comprising a signi cant portion of biomass, can have a more substantial impact on ecosystem functioning than the loss of a similar amount of biomass distributed among various species [24].

In forest management, attention must be paid to the role of dominant species in the relationship between productivity and species diversity. Conducting experiments to identify the competitive roles of dominant species is essential for improving management e ciency in natural ecosystems. When selecting a orestation or forest enrichment, it is crucial to consider species and ecological groups that have similar requirements and can complement each other [28]. This approach can also enhance ecosystem services like enhancing soil fertility, reducing erosion, and providing wildlife habitat [29].

5. CONCLUSION

Plant communities dominated by *D. obtusifolius* and a few other species with poor species composition, diversity ranged from very low to low. Ecologically dominant species play a key role in in uencing the structural properties of wood species and biomass construction capacity. Which, the IVI index of *D. obtusifolius* contributes from 39.14%-71.35%, while biomass contributes from 34.49%-75.46% in each state, they decrease according to forest state, from very poor > poor > medium forest. Based on these results, our study provides information to select and combine plant species for forest quality improvement programs in the study area, especially rocky mountain sites. We also recommend selecting *D. obtusifolius* and *A. roxburghii* when planting in similar site conditions compared to the study area.

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