RELATIONSHIP BETWEEN PLANT BIODIVERSITY AND CARBON STOCKS IN EVERGREEN BROAD-LEAVED FORESTS IN THE CENTRAL HIGHLANDS

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SUMMARY

Forest ecosystems encompass many functions formed by many relationships between abiotic and biotic factors, with plant diversity and carbon stocks being the most important components. Using the plant diversity indices, and biomass functions based on 97 sample plots (OTC) of 500 m^2 (25 m x 20 m) correlation analysis and multivariable regression were used to exploring the relationship between plant biodiversity and carbon stock in the evergreen broad-leaved forest in the Central Highlands. Studies have shown that the total carbon stock depends on the forest state and ranges from 38.93 ± 13.15 tons C/ha to 120.70 ± 32.93 tons C/ha. The results of the diversity indices Simpson (Cd), Shannon-Wiener (H'), Pielou (J'), and Magarlef (d) showed a moderate diversity of the forest states. There was a negative but weak relationship between the carbon stock and the Pielou index (J'). However, there was no statistically significant correlation between Species richness (S), Abundance (A), Simpson (Cd), Shannon-Wiener index (H'), Magarlef (d), and carbon stocks. Therefore, it pointed out that improving the carbon content of forests cannot guarantee the preservation and promotion of plant biodiversity. Preserving plant diversity should therefore be a priority in forest resource management. With the results obtained, the article contributes to creating a robust scientific basis and helping managers plan and develop strategies for the conservation and development of forest capital in the study area.

Keywords: Carbon stock, Central Highlands, evergreen broad-leaved forest, plant diversity, relationship

1. INTRODUCTION

Biodiversity not only has socio-economic and cultural value but also provides many other important benefits such as climate regulation, waste decomposition, reduction of negative impacts of natural disasters, especially the potential for carbon storage. Previous studies have shown that the key biodiversity areas and biodiversity corridors with developed forest vegetation such as the Northeast, Northwest, Central Coast, and Central Highlands are the where total biomass carbon storage is highest (Ministry of Natural Resources and Environment, 2013). The matter is whether there exists a relationship between plant diversity and carbon stocks in these forest vegetation? This is a big issue that has been a concern in many countries around the world. However, this problem remains unexplored in Vietnam.

Biodiversity and carbon stocks play an important role in the context of increasingly complex climate change (Nguyen Van Hop *et al.,* 2020). In Asia, some typical studies on this topic have been carried out by Peh (2009), Shiel and Bongers (2020), Huston (1994), Shahid and Joshi (2017), Pragasan (2020), etc. In Vietnam, this issue was only implemented by Con et al (2013) on objects that were evergreen broad-leaved forest and deciduous forest from the North to South Central. While most of the other studies on plant diversity and carbon stocks have been conducted independently. Simultaneous studies of biodiversity and carbon stocks have been carried out on some vegetation types, but these are still very limited, and inadequate to the potential of forest ecosystem diversity, vegetation types, and land use types in Vietnam, only some of which were carried out by Nguyen Van Hop *et al.* (2020; 2021). However, the relationship between biodiversity and carbon stocks was generally ignored and resolved.

Monitoring, reporting, and reviewing carbon emissions from deforestation and forest degradation are key elements in REDD+ programs. Therefore, evaluating biodiversity as one of the non-carbon benefits of this program, was interested and promoted. In addition, the relationship between carbon stocks and biodiversity has become an important issue in the REDD+ program. Should programs and measures to improve carbon storage capacity through REDD+ be carried out at the same time as activities to promote plant biodiversity (Ram Asheshwar Mandal *et al.,* 2013)? This question should also be clarified when studies on the relationship between plant diversity and carbon stocks are carried out.

In the face of increasingly complex climate change, studying the relationship between biodiversity and carbon stocks has practical and important implications for the REDD+ program. Reality has shown that improving carbon stocks capacity and promoting biodiversity can hardly be done at the same time due to limitations in human resources, finances, management capacities, etc. Therefore, this study was conducted to provide a database for choosing between conserving plant biodiversity or promoting carbon accumulation by assessing carbon stocks, plant biodiversity and exploring their relationships in the evergreen broad-leaved forests of the Central Highlands.

2. RESEARCH METHODOLOGY

2.1. Study sites

This study was carried out from August 2020 to October 2020 in Quang Truc, Quang Tam, Dak Ngo, and Dak R'Tih communes, Tuy Duc district, Dak Nong province (from 12°7'48.90" to 12°10'49.87" N and from 107°21'57.31” to 107°27'52.59” E) (Figure 1). We have collected secondary natural and socio-economic documents of the study site and identified some basic characteristics as follows: The study area was characterized by low mountainous topography, relatively dissected terrain, altitude from 500 – 970 m above sea level, average steepness of 20^o. The site was under the monsoon climate regime rainy season from April to October and dry season from November to March next year. The average annual rainfall was from 2,500 mm to 2,700 mm. The average annual temperature was from 22 to 23^{o}C. The average air humidity was 84%. The total area of the study area was about 7,600 ha, managed by Tuy Duc Forestry Company (before 2007) later managed by Phu Rieng Rubber Company. Until now, forest resources were still disturbed by the activities of local people (Illegal logging, encroaching on forest land for shifting cultivation, etc), especially in regions bordering the arable land of households (Phu Rieng Rubber One Member Limited Liability Company, 2020; Tuy Duc District People's Committee, 2020).

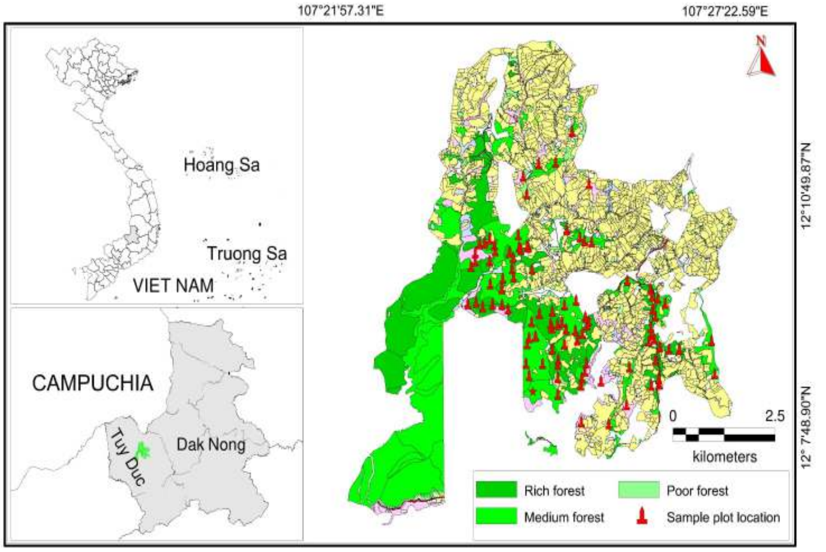

Figure 1. Location of the investigation plots

2.2. Methodology

2.2.1. Field survey

Based on the current forest status map in 2020 of the forest owner (Phu Rieng Rubber One Member Limited Liability Company) and the results of the preliminary survey. The coordinates of the samples were created using the method of typical samples, which represent 3 forest states (rich, medium, and poor forest). Then we arranged the sample plot in the field and adapted it to the investigation site. The coordinates of the sample plots were determined in the field with a GPS locator. A total of 97 temporary typical samples plots were set up in 3 forest states (poor forest: 14 plots, medium forest: 42 plots, and rich forest: 41 plots), each sample plot had an area of 500 m^2 (25 x 20 m) (Mishra, 1968; Sharma, 2003). In each sample plot, information on the species name, diameter at breast height (DBH), overall height (Hvn) of all trees with DBH greater than 5 cm were collected (Bao Huy, 2012). DBH was measured with a contour frame ruler with an error of 0.5 cm, the overall height (Hvn) was measured with a Blume – Leiss ruler with an error of 0.5 m.

2.2.2. Data analysis

Plant species identification: Plant species names were identified by comparative morphological methods. Documents used include An Illustrated Flora of Vietnam, Volumes 1 - 3 (Pham Hoang Ho, 1999-2003), Vietnam Timber Resources (Tran Hop, 2002). The scientific names have been identified and updated online by Kew Science, and World flora online.

Determination of the forest status: Forest statuses were determined following Circular No. 33/2018/TT-BNNPTNT dated 16/11/2018, of the Ministry of Agriculture and Rural Development for the survey, inventory, and monitoring of the developments of forest resources.

Determination of the plant diversity: The Simpson (Cd) (1949), Shannon-Wiener (H') (1963), Pielou index (J'), and Magarlef (d) were calculated with the software Primer 6.16. The Shannon-Wiener diversity (H') was assessed using the classification scale by Fernando (1998): low (H' = 1 – 2.49), moderate (H' = 2.5 – 2.99), high (H' = 3 – 4).

Estimation of biomass and carbon stocks: The aboveground biomass (AGB) and the belowground biomass (BGB) of each tree were determined by the biomass function (1) and (2) from Bao Huy (2012), which was applied to the evergreen broad-leaved forest in the Central Highlands. The aboveground carbon stocks C(AGB) and belowground carbon stocks C(BGB) of trees were calculated according to the formulas (3) and (4) (IPCC, 2006). The total carbon stock accumulated in biomass was calculated according to the formula (5).

$$AGB\ (kg/tree) = \exp(-2{,}23927 + 2{,}49596*\ln(DBH)) \qquad (1)$$

$$\text{Where: } DBH = 5 – 75cm,\ n = 161\ trees,\ R^2 = 0{,}95 \qquad (2)$$

$$BGB\ (kg/tree) = \exp(-3{,}73687 + 2{,}32102*\ln(DBH)) \qquad (3)$$

$$\text{Where: } DBH = 5 – 75cm,\ n = 105\ trees,\ R^2 = 0{,}90$$

$$C(AGB)\ (kg\ C/tree) = AGB\ (kg/tree)*0{,}47$$

$$C(BGB)\ (kg\ C/tree) = BGB\ (kg/tree)*0{,}47 \qquad (4)$$

$$Mc(kg\ C/tree) = C(AGB)\ (kg\ C/tree) + C(BGB)\ (kg\ C/tree) \qquad (5)$$

Where: AGB, BGB: aboveground and belowground biomass; C(AGB), C(BGB): Aboveground and belowground carbon stocks; Mc: total carbon stocks; DBH (cm): diameter at breast height; 0.47: IPCC carbon value coefficient.

Determination of the relationship between plant diversity and carbon stocks: Excel was used to calculate volume, and carbon stocks. Phân tích ANOVA in SPSS software version 23 was used to compare the difference in plant diversity indices and carbon stocks between forest states according to the Tukey-B standard (Bao Huy, 2017). The relationships between carbon and diversity were assessed using Pearson correlations in the R software (Bao Huy, 2017).

3. RESULTS

3.1. Carbon stocks among forest states

For DBH and Hvn, the highest value was 17.19 ± 2.60 cm and 13.44 ± 2.06 m was in the rich forest, the lowest 14.18 ± 4.94 cm and 10.78 ± 2.35 m was in the poor forest, respectively. The results of the ANOVA analysis according to Tukey-B criteria show that there was a significant difference between rich forests with poor forests, and between rich forests with medium forests (P-value < 0.05). There was no statistically significant difference between medium and poor forest (P-value > 0.05). There was a statistically significant difference in forest stand volumes between the three states (P-value < 0.05). We found the highest volumes of 263.50 ± 61.09 m^3/ha was in the rich forests, the lowest 71.61 ± 23.62 m^3/ha was in the poor forests (Figures 2a, 2b, and 2c).

C(AGB) and C(BGB) fluctuated depending on the forest status and ranged from 34.39 ± 11.72 tons C/ha and 4.54 ± 1.45 tons C/ha in the poor forest to 107.73 ± 30.03 tons C/ha and 2.97 ± 2.95 tons C/ha in the rich forest, and the total carbon stocks (Mc) also change depending on the forest state. We found that the highest carbon accumulation capacity of 123.20 ± 33.28 tons C/ha was in the rich forest, the lowest 37.58 ± 13.42 tons C/ha was in the poor forest (Figure 2d, 2e, and 2f).

Using ANOVA analysis according to the Tukey-B standard, we discovered that C(AGB), C(BGB), and the total carbon stock (Mc) of the poor, medium, and rich forests were significantly different (P-value < 0.05) (Figure 2d, 2e, and 2f).

3.2. Plant diversity in forest states

We recorded a total of 4275 individual trees of 127 species in the study area. In that, 124 species were identified at the species level and 3 species were not identified. Among them, the number of trees and species in the rich forest (1917 trees, 96 species) and medium forest (1835 trees, 97 species) were quite similar, the lowest was the poor forest (523 trees, 71 species). Of the 127 tree species found, 53 species co-occur in all 3 forest states. A total of 6 dominant species were identified in the study area including *Castanopsis echinophora* A.Camus, *Schima superba* Gardner & Champ., *Syzygium hancei* Merr. & L.M. Perry, *Xerospermum noronhianum* (Blume) Blume, *Cinnamomum burmanni* (Nees & T.Nees) Blume, *Machilus odoratissima* Nees. The number of dominant and co-dominant species was quite similar between forest states (Rich and medium forests had 5 species, poor forests had 4 species). However, the ecological role of each species in each forest state was different. In which, *Schima superba* Gardner & Champ was the dominant species in the rich forest, *Castanopsis echinophora* A.Camus in the medium and poor forest.

Species richness (S), Shannon-Weiner (H') and Magarlef index (d) were highest in the medium forest 14.81 ± 3.78; 2.31 ± 0.35; 3.67 ± 0.91, respectively and lowest in the poor forest 13.50 ± 5.61; 2.17 ± 0.48; 3.45 ± 1.20, respectively. For Abundance (A) was highest in the rich forest (45.78 ± 13.56) and lowest in the poor forest (37.14 ± 15.69). The Pielou index (J') was highest in the poor forests (0.87 ± 0.07), and the lowest was in the rich forests (0.78 ± 0.23). Meanwhile, for the Simpson's index (Cd) the highest was found in the poor forest (0.17 ± 0.09) and the lowest in the medium forest (0.14 ± 0.07).

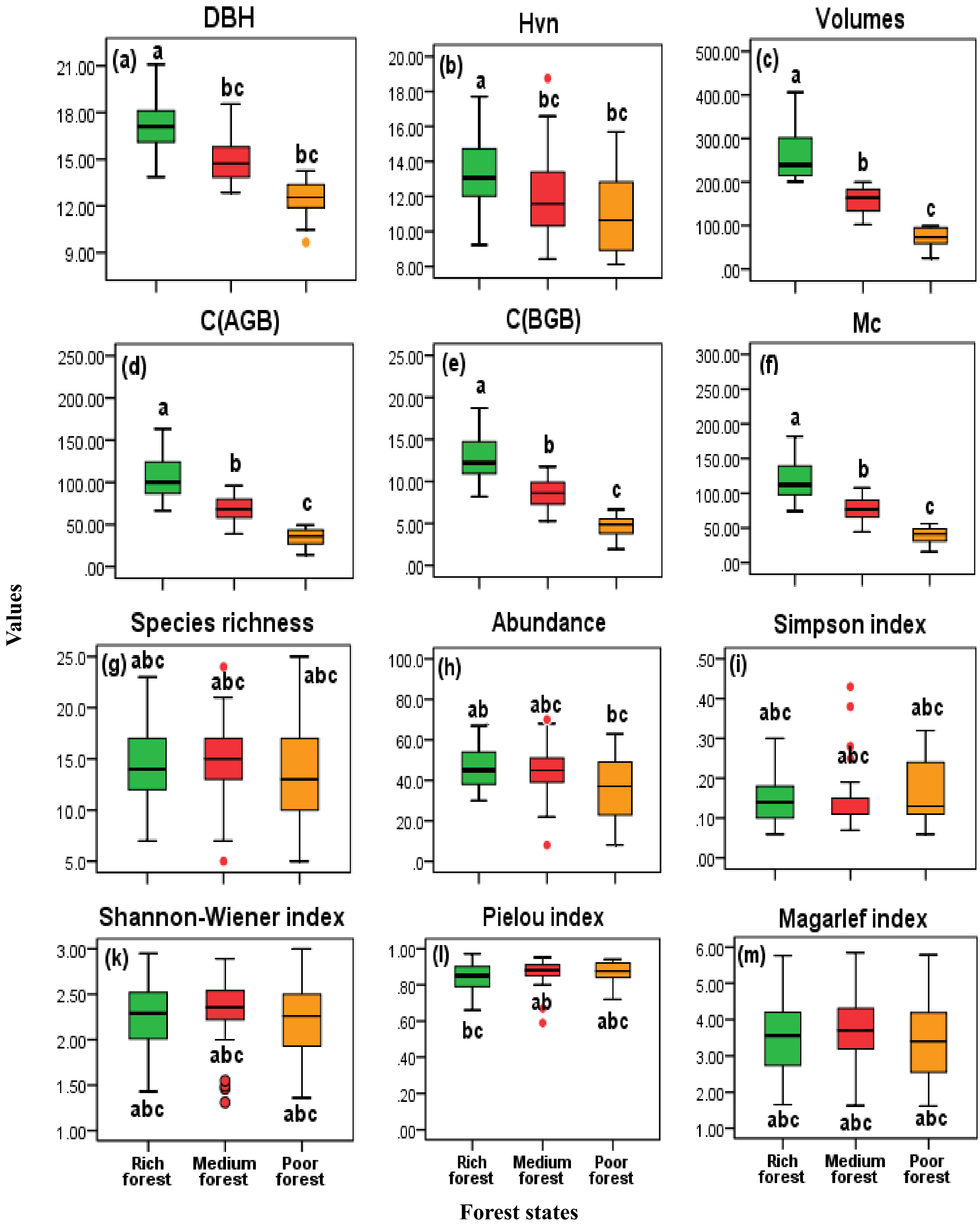

Figure 2. Comparison of DBH, Hvn, Volumes, C(AGB), C(AGB), Mc, and some diversity indices between forest states

(Legend: The different letters a, b, and c show a statistically significant difference (P-value < 0.05); (a)-DBH; (b)-Overall height (c)- Volumes; (d)- Above ground carbon stock; (e)-Below ground carbon stock; (f)-total of carbon stocks; (g)-Species richness; (h)-Abundance; (i)-Simpson index; (k)-Shannon-Wiener index; (l)-Pielou index; (m)-Magarlef index)

Although there were differences in the values of the (S), (A), (H'), (Cd), and (d) indices between rich, medium, and poor forests. These differences were not statistically significant

(P-value > 0.05). Meanwhile, the Pielou index (J') showed a statistically significant difference between the rich and medium forest states (P-value < 0.05). However, we did not find any statistically significant difference between rich forest and poor forest and between poor forest and medium forest (P-value > 0.05) (Figure 2g, 2h, 2i, 2k, 2l, 2m).

3.3. The relationship between plant diversity and carbon stocks

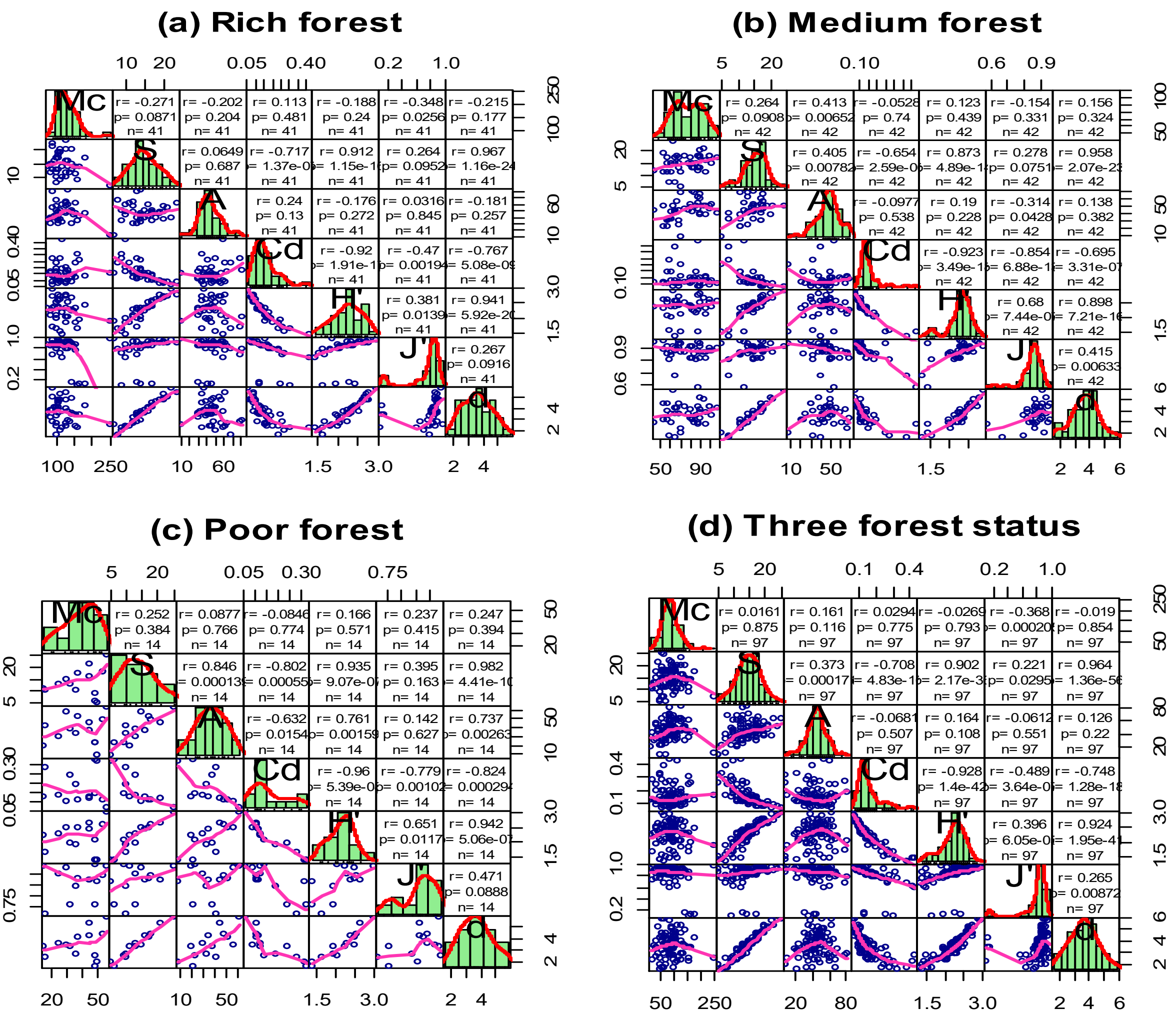

Figure 3. The relationship between plant biodiversity and carbon stocks in the forest states and entire study areas

(Legend: Mc-a total of carbon stocks; S-species richness; A-Abundance; Cd-Simpson; H'-Shannon-Wiener; J'-Pielou; d-Magarlef)

For each type of forest status, the analysis results showed that there was a negative but weak correlation between the total carbon stock and the Pielou index (J') in rich forests (r = -0.348, P-value < 0.05), abundance (A) in the medium forest (r = -0.413, P-value < 0.05). In other states, howerver, this correlation did not exist (P-value > 0.05). We also found no relationship between total carbon stocks and the Simpson (Cd), Shannon-Weiner (H'), and Magarlef (d) indices in all forest states (Figures 3a, 3b, and 3c).

For the whole study area, when examining the relationship between the indices of plant biodiversity with the carbon stock for the entire region, we found a statistically significant but weakly negative correlation between the (J') index and the carbon stock (r = -0.388, P-value < 0.001). While, there was no statistically significant correlation (P - value > 0.05) between species richness, abundance, (H'), (Cd), and (d) index with the carbon stock (Figure 3d).

4. DISCUSSION

Carbon stocks

The results of the determination of carbon stocks showed the important ecological role of evergreen broad-leaved forests as potential carbon stores. The highest carbon stocks were found in the rich forests, followed by the medium forests and the lowest in the poor forests. The highest carbon stocks were recorded in the former forest state, which may be due to the stand density together with diameter sizes larger than medium and poor forests. In this study, carbon stocks were unevenly distributed in the forest states. This could be explained by the heterogeneity in number, species composition, density, in particular individual tree size.

C(AGB), C(BGB), and total carbon stock (Mc) differ significantly between the forest states. In general, the stand density and diameter size of the rich forest status was higher than that of the medium forest and the poor forest status. This increases the total carbon stock of the ecosystem. The general trend observed in the three forest states indicated that C(AGB) contributed over 88.96% of the total carbon stock accumulated from woody plants (Figure 2d, 2e, 2f). This result agreed with the results of Ram Asheshwar Mandal *et al.* (2013), who reported C(AGB) contributed at least 88.01% of the total carbon stocks.

We found that the carbon stocks in the present study were lower than some forest types in the Central Highlands carried out by Vo Dai Hai and Dang Thinh Trieu (2011): from 74.21 tons C/ha to 244.83 tons C/ha in the evergreen broad-leaved forest; from 141.54 tons C/ha to 190.22 tons C/ha in the semi-evergreen forest; from 57.55 tons C/ha to 158.41 tons C/ha in the deciduous forest; In deciduous forest states of Yok Don National Park, Dak Lak province, on the other hand, carbon stocks ranging from 36.26 tons C/ha to 198.80 tons C/ha were recorded (Nguyen Viet Luong *et al.,* 2018). The results obtained were also lower than those of the dominant forest *Shorea roxburghii* in the Southeast region (Nguyen Van Hop *et al.,* 2020). This result could be explained by the influence of the selective harvesting system in the 1980s - 1990s of the 20th. On the other hand, the studies were carried out under different ecological conditions, so that the estimated carbon stocks obtained were different (Nguyen Van Hop *et al.,* 2021). In addition, differences in species composition, canopy structure, and soil in different regions could also produce different carbon stocks (Tran Quang Bao & Nguyen Van Thi, 2013).

Plant biodiversity

The results of the analysis of the diversity indicators showed that the plant biodiversity, especially in the forest states and in the entire study area, in general, was classified as moderate according to the classification scale by Fernando (1998).

We found that the variety of woody plants in this study matched that of Nguyen Van Hop *et al.* (2021) in the evergreen broad-leaved forest (H' = 2.14) in Quang Tam commune, Tuy Duc district; reported by Pham Van Huong *et al.* (2021) in the sub-tropical moist evergreen broad-leaved closed forest (H' = 2.57) in Ta Dung National Park; The study was carried out in 2020 in the *Shorea roxburghii* dominant forest (H' = 2.94) of the tropical moist evergreen closed forest in Dong Nai (Nguyen Van Hop *et al.,* 2020). However, we also found significant differences from some studies reported in Southern Vietnam: Vuong Duc Hoa and Vien Ngoc Nam (2018) found a high diversity of woody plants (H' = 3.24) in tropical moist evergreen and semi-evergreen closed forests in Bu Gia Map National Park; Nguyen Van Hop (2017) discovered a high level of diversity (H' = 3.58) in the sub-type pygmy forest in Bidoup-Nui Ba National Park. This was explained by the woody plant diversity influenced by environmental factors (latitude, precipitation, altitude). If environmental factors changed, the plant diversity would change through composition, number of species, number of individual plants, etc. (Begon *et al.,* 1986; Abebe, 2005; Nguyen Van Hop *et al.,* 2020). In addition, plant diversity was determined depending on the type of forest vegetation (Nguyen Van Hop *et al.,* 2020; Nguyen Van Hop *et al.,* 2021; Vuong Duc Hoa & Vien Ngoc Nam, 2018), species competition, structure and development stages of plant communities (Begon *et al.,* 1986), management strategies, socio-economic economic factors (Abebe, 2005). However, unclear differences in species diversity between ecoregions could be related to unclear differences in species structure and composition of woody plant species (Nuberg *et al.,* 2009).

The relationship between plant biodiversity and carbon stocks

Plant diversity is an important factor in regulating the function and use of forest ecosystems. Our results showed a complex and fluctuating relationship between carbon stocks and species diversity in evergreen broad-leaved forests. Some sample plots showed high diversity but relatively low carbon stocks, while others, conversely, shower low diversity but high carbon stocks. This finding was supported by the study by Yikunoamlak Gebrewahid & Esayas Meressa (2020) in the parkland agroforestry in Northern Ethiopia.

We found a negative but weak correlation between carbon stocks and the (J') index in the rich forest state. However, we did not find any statistically significant association between the Shannon-Weiner (H') and Simpson (Cd) indices and total carbon stocks in all forest states. The study conducted by Ram Asheshwar Mandal *et al*. (2013) also showed that there was a weak correlation between carbon stock and the (J') index. Poorter *et al.* (2015) found not a significant correlation between the Shannon and Simpson indices and carbon stocks across in the tropics. This discovery was comparable to previous analyzes by Poorter *et al.* (2015), Sullivan *et al.* (2017) in tropical regions.

The relationship between carbon stocks and the (J') index showed a significant but weak negative in the entire region. However, the Shannon-Weiner and Simpson diversity index showed no statistically significant correlation with carbon stocks in all forest states. This finding was supported by a study conducted by Heather *et al.* (2010) in the subtropical forest of Puerto Rico, and the report was prepared by Yikunoamlak Gebrewahid & Esayas Meressa (2020) in the parkland agroforestry in Northern Ethiopia.

In the present study a 500 m^2 sample plot was used to analyze the relationship between carbon stocks and plant biodiversity. The results showed that no relationship was found between these two variables. This result agreed with the study by Sullivan *et al.* (2017), who used subplots with an area of 400 m^2, which were divided by a sample plot of 1 ha (10,000 m^2). They found no correlation between carbon stocks and plant biodiversity in the Amazon region, Africa, and all of the world’s tropical forests. The report by Ram Asheshwar Mandal *et al.* (2013) also used a sample plot size of 500 m^2 and also found no statistically significant correlation between carbon stocks and plant biodiversity. The lack of clear diversity-carbon relationships on conservation planning scales means that carbon-centered conservation strategies inevitably miss out on many highly diverse ecosystems (Sullivan *et al.,* 2017). However, the results found in Asia also by Sullivan *et al.* (2017), showed that there exists a weak positive relationship between these two variables. This suggests that diversity effects in tropical forests can be scale-dependent (Sullivan *et al.,* 2017).

The present study showed that species richness (S) for each forest state and all three forest states does not correlated with the carbon stocks. Our finding contradicts the results of Sullivan *et al.* (2017) and Poorter *et* *al.* (2015), and Con *et al.* (2013), who found a statistically significant influence between species richness and forest productivity. The discrepancy in these results can be influenced by environmental factors such as climate, soil, and disturbances (Talbot, 2010).

In this study, there was no statistically significant correlation between carbon stocks and Species richness, the Shannon and Simpson, and Magarlef diversity indices. This indicated that plant biodiversity was less important in predicting carbon storage capacity. Therefore, further studies are needed in different ecosystems and vegetation types are needed to draw conclusions about the relationship between plant biodiversity and carbon stocks in Southern Vietnam in particular and Vietnam in general.

With the findings of determining the association between carbon diversity combined with the function of a biodiversity conservation forest. We recommend prioritizing biodiversity conservation over promoting forest productivity. This is a "wise" choice based on "nature", which both meets the aim of biodiversity conservation while maintaining the forest's carbon-accumulating capacity through maintaining and enhancing the forest area natural forests in the study area by minimizing forest fires, preventing human impacts, planting native trees, etc.

5. CONCLUSION

We found statistically significant differences in C(AGB), C(BGB), and total carbon stocks (Mc) in the evergreen broad-leaved forest states. In which, the highest carbon accumulation was found in the rich forests and the lowest in the poor forests.

No statistically significant differences in the plant diversity indices were found in the present study. Moderate plant diversity was found in all forest states. The highest (H') index was determined in medium forests and the lowest in poor forests.

The relationship between carbon stocks and the (J') index showed a significantly negative but weak relationship in the entire region. However, the relationship of Species richness (S), Abundance (A) Shannon-Weiner (H'), Simpson (Cd), Magarlef's (d) diversity index, and carbon stocks was not found to be significant. This may be due to the "gap effect", besides, disturbed habitat can also be considered as a factor influencing this relationship. Therefore, the study showed that increasing forest carbon cannot guarantee the conservation and promotion of biodiversity. It was, therefore, necessary in nature conservation management to focus and prioritize the protection and promotion of biodiversity.

REFERENCES

1. Abebe, T. (2005). Diversity in home garden agroforestry systems of Southern Ethiopia (Ph.D. dissertation). The Netherlands: Wageningen University.

2. Tran Quang Bao and Nguyen Van Thi (2013). The CO_2 sequestration capacity of the Nature forest in Muong La district, Son La province. Journal of Forestry Science and Technology, (2): 60- 69.

3. Begon, M., Haper, J.L., Townsend, C.R. (1986). Ecology: Individuals, Populations and Communities. Blackwell Scientific Publications.

4. Con, T. Van, Thang, N. T., Ha, D. T. T., Khiem, C. C., Quy, T. H., Lam, V. T. Sato, T. (2013). Relationship between aboveground biomass and measures of structure and species diversity in tropical forests of Vietnam. Forest Ecology and Management, 310, 213–218. https://doi.org/10.1016/j.foreco.2013.08.034

5. Fernando, E. (1998). Forest Formations and Flora of the Philippines. College of Forestry and Natural Resources. University of the Philippines Los Banos (unpublished).

6. Vo Dai Hai and Dang Thinh Trieu (2015). Study on carbon sequestration capacity of evergreen broad-leaved, semi-evergreen, and deciduous forests in the Central Highlands. The report summarizes the results of the research topic at the ministerial level.

7. Heather, D. V., Michael, R. W., Stephen, B. C., Ariel, E. L., & Frederick, N. S. (2010). Relationship between aboveground biomass and multiple measures of biodiversity in subtropical Forest of Puerto Rico. Biotropica, 42(3): 290–299.

8. Vuong Duc Hoa and Vien Ngoc Nam (2018).

Biodiversity of plants and specific structures of close evergreen tropical rainforest and semi-closed evergreen humid tropical forest in Bu Gia Map National Park, Binh Phuoc Province, Journal of Agriculture and Rural Development, 1(8): 122-131.

9. Pham Hoang Ho (1999-2003). An Illustrated Flora of Vietnam (Volume 1-3), 2nd ed, Young Publishing House, Hanoi, Vietnam.

10. Nguyen Van Hop (2017). Some timber tree characteristic of the pygmy forest type in Bidoup - Nui Ba National Park, Lam Dong province, Journal of Forestry Science and Technology, (3): 27-35.

11. Nguyen Van Hop, Bui Manh Hung, Huynh Quoc Trong (2020). Diversity of Lauraceae family in Hon Ba Nature Reserve, Khanh Hoa province, Journal of Forestry Science and Technology, (9): 44-52.

12. Nguyen Van Hop, Bui Huu Quoc, Nguyen Van Quy (2021). Woody plant diversity and aboveground carbon stock in the evergreen broad-leaved forest in Tuy Duc district, Dak Nong province. Journal of Forestry Science and Technology, (1): 92-101.

13. Nguyen Van Hop, Le Hong Viet, Tran Quang Bao, Nguyen Thi Luong (2020). Woody plant diversity and aboveground carbon stocks of (*Shorea roxburghii* G. Don) dominant forests in Tan Phu, Dong Nai province. Journal of Forestry Science and Technology, (10): 66-76.

14. Tran Hop (2002). Timber resources in Vietnam. Agricultural Publishing House, Hanoi.

15. Pham Van Huong, Tran Thi Bich Nguyet, Kieu Phuong Anh, Pham Thi Luan (2021). Structural characteristics and diversity of wooden trees layer of the tropical evergreen broad-leaved closed forest in Ta Dung National Park, Journal of Forestry Science and Technology, (1): 36-43.

16. Bao Huy (2012). Determining the amount of CO2 absorbed in evergreen broadleaf forests in the Central Highlands as the basis for participating in the program to reduce emissions from degradation and deforestation. Final report on Science and Technology subject at ministerial level (Code: B2010 - 15 - 33TD), Tay Nguyen University.

17. Huston, M. A. (1994). Biological Diversity: The coexistence of species on changing landscapes. Cambridge: Cambridge University Press.

18. Bao Huy (2017). Statistical Informatics in Forestry. Scientific and Technical Publishing Housers.

19. IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme (Eds. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe). IGES, Japan. Retrieved 5 September 2009 from http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

20. Kew science (2021). <http://www.plantsoftheworldonline.org>. Accessed March 2021.

21. Nguyen Viet Luong, To Trong Tu, Trinh Xuan Hong, Le Tran Chan, Tong Phuc Tuan, Nguyen Huu Tu (2018). Potential of CO2 sequestration of some forest types in National Parks and Biosphere Reserves in Vietnam. Environmental Journal, (2): 1-5.

22. Ministry of Natural Resources and Environment (2013). Decision 1250/2013 of the Prime Minister dated 31/07/2013 approving the National Strategy on Biodiversity to 2020, vision to 2030. Hanoi, Vietnam.

23. Mohommad Shahid and Shambhu Prasad Joshi (2017). Relationship between Tree Species Diversity and Carbon Stock Density in Moist Deciduous Forest of Western Himalayas, India. Journal of Forest and Environmental Science Vol. 33(1): 39-48. https://doi.org/10.7747/JFES.2017.33.1.39

24. Nuberg, I., George, B., & Reid, R. (2009). Agroforestry for natural resource management. Australia: CSIRO publishing.

25. Peh, K. S.-H. (2009). The Relationship between Species Diversity and Ecosystem Function in Low- and High-diversity Tropical African Forests. School of Geography, Submitted, 228. Retrieved from http://www.pik-potsdam.de/news/public-events/archiv/alter-net/alumni/peh_kelvin_thesis.pdf.

26. Phu Rieng Rubber One Member Limited Liability Company (2020). Report summarized the first 6 months of 2020.

27. Poorter, L., Van der Sande, M.T., Thompson, J., Arets, E.J.M.M., Alarcón, A., Álvarez-Sánchez, F.J., Peña-Claros, M., (2015). Diversity enhances carbon storage in tropical forests. Global Ecology and Biogeography, 24(11): 1314–1328. https://doi.org/10.1111/geb.12364.

28. L. Arul Pragasan (2020). Tree carbon stock and its relationship to key factors from a tropical hill forest

of Tamil Nadu, India. Geology, ecology, and landscapes. https://doi.org/10.1080/24749508.2020.1742510

29. Ram Asheshwar Mandal, Ishwar Chandra Dutta, Pramod Kumar Jha, and Siddhibir Karmacharya (2013). Relationship between Carbon Stock and Plant Biodiversity in Collaborative Forests in Terai, Nepal. ISRN Botany. http://dx.doi.org/10.1155/2013/625767

30. Simpson, E.H. (1949). Measurement of diversity. London: Nature.

31. Shannon, C.E., and Wiener, W. (1963). The mathematical theory of communities. Illinois: Urbana University, Illinois Press.

32. Sheil, D., & Bongers, F. (2020). Interpreting forest diversity-productivity relationships: volume values, disturbance histories and alternative inferences. Forest Ecosystems, 7(1). https://doi.org/10.1186/s40663-020-0215-x

33. Sullivan, M.J.P.P., Talbot, J., Lewis, S.L., Phillips, O.L., Qie, L., Begne, S.K., Zemagho, L., (2017). Diversity and carbon storage across the tropical forest biome. Scientific Reports 7 (1), 39102. https://doi.org/10.1038/srep39102.

34. Talbot, J.D. (2010). Carbon and biodiversity relationships in tropical forests. Multiple Benefits Series 4. Report prepared on behalf of the UN-REDD Programme.School of Geography, University of Leeds, Leeds / UNEP World Conservation Monitoring Centre. Cambridge, UK.

35. Tuy Duc District People's Committee (2020). Report on the economic and social situation in the first 6 months of 2020.

36. World flora online (2021). <http://104.198.148.243>. Accessed March 2021.

37. Yikunoamlak Gebrewahid & Esayas Meressa (2020). Tree species diversity and its relationship with carbon stock in the parkland agroforestry of Northern Ethiopia. Cogent Biology, (6): 1, 1728945

MỐI LIÊN HỆ GIỮA ĐA DẠNG SINH HỌC THỰC VẬT VÀ TRỮ LƯỢNG CARBON TRONG RỪNG LÁ RỘNG THƯỜNG XANH Ở TÂY NGUYÊN

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TÓM TẮT

Hệ sinh thái rừng bao gồm nhiều chức năng được hình thành bởi nhiều mối quan hệ giữa các yếu tố vô sinh và hữu sinh, trong đó đa dạng thực vật và trữ lượng cacbon là thành phần quan trọng nhất. Thông qua các chỉ số đa dạng thực vật và hàm sinh khối, dựa trên 97 ô mẫu (OTC) 500 m^2 (25 m x 20 m), cùng với đó, phân tích tương quan và hồi quy đa biến đã được sử dụng để thăm dò mối quan hệ giữa đa dạng sinh học thực vật và trữ lượng carbon trong rừng lá rộng thường xanh ở Tây Nguyên. Kết quả nghiên cứu cho thấy tổng trữ lượng carbon phụ thuộc vào trạng thái rừng, dao động từ 38,93 ± 13,15 tấn C/ha đến 120,70 ± 32,93 tấn C/ha. Các chỉ số đa dạng Simpson (Cd), Shannon-Wiener (H'), Pielou (J') và Magarlef (d) được tính toán cho thấy, tính đa dạng của các trạng thái rừng ở mức trung bình. Có một mối quan hệ tiêu cực nhưng yếu giữa trữ lượng carbon và chỉ số Pielou J'. Trong khi không tồn tại bất kỳ mối tương quan có ý nghĩa thống kê nào giữa độ giàu loài (S), độ phong phú (A), chỉ số Simpson (Cd), Shannon-Wiener (H'), Magarlef (d) và trữ lượng carbon. Vì vậy, kết quả này chỉ ra rằng việc tăng cường carbon rừng không thể đảm bảo cho việc bảo tồn và thúc đẩy đa dạng sinh học thực vật. Vì vậy, trong quản lý tài nguyên rừng cần tập trung ưu tiên bảo tồn đa dạng thực vật. Với những kết quả thu được, bài báo góp phần cung cấp những cơ sở khoa học đáng tin cậy, giúp các nhà quản lý hoạch định chính sách và xây dựng chiến lược bảo tồn và phát triển vốn rừng tại khu vực nghiên cứu.

Từ khóa: đa dạng thực vật, mối liên hệ, rừng thường xanh, Tây Nguyên, trữ lượng carbon

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