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Research Article

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Analysis of tree vegetation and stored carbon in Pasir Nunang village forest, Southeast Aceh district

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ABSTRACT

To date, no scientific studies have been conducted to determine tree species richness and carbon content in the Pasir Nunang Village Forest, Southeast Aceh Regency, Aceh Province. This study aims to determine the tree species diversity index and carbon content in the Pasir Nunang Village Forest, Southeast Aceh Regency, Aceh Province. Quantitative research then research a purposive sampling method was employed, taking into account variations in topography and slope. Research data sample at the research locations in the north and south were made into plots measuring 40 m x 40 m on the right and left of the transect in a zigzag manner without any intervals of 10 plots, resulting in a total of 20 plots at the research location. Field data collection was conducted from June 22 to July 10, 2024, within the forest area of Pasir Nunang Village, Southeast Aceh Regency. Data collection through observations was conducted on tree stands with a diameter of >20 cm, measuring the tree trunk diameter at chest height of an adult. Data analysis included the calculation of vegetation species diversity index (Shannon–Wiener, H') and carbon storage was analyzed using allometric equations. The results identified a total of 28 tree species belonging to 16 families, comprising 162 individual trees.The Shannon–Wiener diversity index (H') reached a maximum value of 3.12. The estimated total aboveground carbon stock in the Pasir Nunang Village Forest was 354.23 tons ha^{-1}.

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INTRODUCTION

The presence of forests around the world provides various benefits for human life. As part of the ecosystem, forests are home to millions of species of plants and animals that inhabit this planet. Forests in Indonesia function as a source of oxygen needed by humans and are able to absorb dangerous carbon

dioxide. In addition, forests also play a role in storing water sources and regulating climate change throughout the world. Green Open Spaces (Green Open Spaces) are areas or land surfaces dominated by plants that are developed to protect specific habitats, environmental/urban facilities, infrastructure networks, and agricultural cultivation (Andini, et al., 2018).The impacts of climate change are very pronounced and affect many aspects of life, such as the decreasing availability of clean water, decreasing biodiversity, and increasing risk of natural disasters.

Climate change affects ecosystems, social interactions, and the survival of other living things (Wahyuni & Suranto., 2021). Climate change is currently one of the biggest international problems facing the world causing various impacts including the Greenhouse effect or what is known as the green house effect is a condition in which the average temperature of the earth's surface experiences a significant increase (Wulandari et al., 2024). This increase in temperature is caused by the increasing amount of carbon dioxide (CO2) and other gases in the atmosphere. Global warming and climate change that are currently occurring on Earth are influenced by carbon dioxide (CO2) emissions and other greenhouse gases produced by human activities. These daily activities, often without us realizing it, contribute to temperature changes. One example of such activities is changes in land use (Adimas et al., 2023).

Through the process of photosynthesis, plants absorb carbon and convert it into organic carbon in the form of biomass. Biomass is a way to absorb energy that can be converted into carbon.The key factor that greatly determines the rate of reduction of carbon dioxide (CO2) accumulation in the atmosphere is through the storage process carried out by various types of trees in the forest. The level of CO2 in the atmosphere can be processed through photosynthesis that occurs in trees, where trees in the forest act as carbon absorption areas, known as the carbon decomposition process. The process of storing and absorbing carbon in growing trees is called carbon sequestration. The quality and amount of carbon that can be stored in each part of the tree is greatly influenced by the type and characteristics of the tree itself (Maruapey et al., 2024).

The area of forest in Indonesia continues to decrease every year. As a result, the existence of forests is increasingly threatened. Many forests in Indonesia have experienced forest conversion in the fields of plantations and livestock. Many news reports about disasters that befall communities are caused by our own actions that do not preserve nature. Natural disasters such as flash floods, droughts, crop failures, forest fires are natural disasters that occur very often (Nakita et al., 2022).

Vegetation analysis is a way to collect quantitative information about each plant species in a vegetation community. This method is also applied to study the species composition and vegetation structure or plant growth patterns in a particular community or area. Plant potential is one of the important information and data needed in developing forest management models. Research on plant potential often uses several parameters such as density (number of individuals in one area), frequency (comparison of the number of samples of a particular species to the total sample), dominance of cover (comparison of the basal area inhabited by a species to the total area of habitat) and the Important Value Index (INP). The INP obtained from the sum of the relative density, relative frequency, and relative dominance values is a quantitative parameter that shows the level of dominance of a species in a plant community (Hamka & Anwar, 2024).

In the Nunung village area in Lawe Alas sub-district, Southeast Aceh regency, based on the results of researcher observations, many trees have died and fallen due to deforestation, resulting in flash floods and landslides that occur almost every year. Researchers are interested in analyzing the structure and composition of tree vegetation and carbon potential in the Pasir Nunang Village forest, Southeast Aceh Regency because areas and habitats around the damaged forest can also experience flooding. In

addition, forest damage also interferes with the forest's function as a water absorption area (Fitriandhini & Putra 2022). Causes of forest damage include climate change, global warming, and a decrease in the indirect benefits of the forest. One of the forestry conflicts, namely encroachment and illegal logging, also occurs in the Lamongan mountain forest area located in Klakah sub-district. What is very concerning is the impact of forest damage and environmental degradation, which has caused various social and environmental disasters such as floods, landslides, and prolonged droughts (Winarwan et al., 2021).

One of the areas located in Aceh province and directly bordering North Sumatra province is Southeast Aceh. Pasikh Nunang Village Forest, located in Southeast Aceh Regency. This study aims to determine the tree species diversity index and carbon content in the Pasir Nunang Village Forest, Southeast Aceh Regency, Aceh Province.This forest area consists of high cliffs and steep valleys. Pasir Nunang Forest is surrounded by mountains and valleys that are quite steep and crossed by quite fast flowing tributaries, so that half of the total area of this forest is almost untouched by humans (Yassir & Asnah, 2018).

RESEARCH METHODS

The location for the study was determined using the purposive sampling method (Sugiyono, 2018). Type quantitative research then research Purposive sampling is a selective way to choose a research location that is considered representative. he purposive sampling technique is to choose a location deliberately so that each type of vegetation such as shrubs, small trees, and large trees has the opportunity to be taken as a research sample (Fatwa et al., 2024). The research was conducted in the forest area of Pasikh Nunang Village, Southeast Aceh Regency located at an altitude of ± 40-400 m above sea level. Data collection was carried out from June 22 to July 10, 2024. Research data at the research locations in the north and south were made into plots measuring 40 m x 40 m on the right and left of the transect in a zigzag manner without any intervals of 10 plots, resulting in a total of 20 plots at the research location. Data collection through observations were made on tree stands with a diameter of > 20 cm and measuring the diameter of the tree trunk at chest height of an adult.

The data analysis technique to determine the richness of tree species and to determine the carbon content carried out in the Pasir Nunang Village Forest, Southeast Aceh District, Aceh Province is by using species diversity index (Shannon–Wiener, H') and carbon storage was analyzed using allometric equations. Specimens from all individuals that have been collected are then arranged and wrapped in newspaper and placed in plastic bags and given 70% alcohol until wet. The air in the bags was removed, then sealed with duct tape, and then transported to the laboratory for drying and identification. The abiotic factors measured include air temperature with a thermometer, air humidity with a hygrometer, soil humidity and pH with a soil tester, soil temperature with a soil thermometer, light intensity with a luxmeter, and altitude with an altimeter.

The collected vegetation data were analyzed to obtain the Relative Density (KR), Relative Frequency (FR), Relative Dominance (DR), Important Value Index (INP), Diversity Index, and Uniformity Index values from each research location (Zakia et al., 2024). IS is considered different when its value reaches 0% and in general a community is considered similar if its value is more than 75% (Kusmana et al., 2021).

FINDING AND DISCUSSION

Based on the study conducted in the mountains of Pasikh Nunang Village, Lawe Alas District, Southeast Aceh Regency, 28 types of trees from 16 families with a total of 162 individuals per 1.6 hectares

were identified. The diversity of tree species found in the forest area of Pasikh Nunang Village, Southeast Aceh Regency.

Table 1.Tree Species Wealth in Pasikh Nunang Village Forest, Southeast Aceh Regency

Family	Type Name	Number of Individuals
Anonaceae	*Picrasma javanica*	7
Celastreceae	*Lophopetalum javanicum*	2
Combretaceae	*Terminalia catappa*	6
Dipterocarpaceae	*Parashorea lucida*	6
Euphorbiaceae	*Baccaurea deflexa*	4
	Mallotus sp.	5
	Macaranga tanarius	9
Fagaceae	*Quercus sp.*	3
	Castanopsis sp.	3
	Lithocarpus sp.	3
Lauraceae	*Eusideroxylon zwargeri*	21
Malvaceae	*Pterospermum javanicum*	5
	Mastixia trichotoma	3
Meliaceae	*Canarium denticulatum*	7
Moraceae	*Arthocarpus nitidus*	1
	Aglaia racemose	4
	Aglaia racemose	4
	Antiaris toxicaria	5
	Arthocarpus sp.	3
	Dalbergia latifolia	2
	Arthocarpus elasticus	8
	Ficus sp.	4
Myrtaceae	*Bichotan charcoal*	14
Myristicaceae	*Corymbia opaca*	7
Rubiaceae	*Canarium odoratum*	6
Sapindaceae	*Pometia pinnata*	11
Sapotaceae	*Payena lucida*	1
Sterculiaceae	*Abroma sp.*	8
Jumlah Jenis		28
Jumlah Total Individu		162

The Table 1 above shows that the number of tree species at the research location is relatively lower, when compared to the results of similar studies that have been conducted previously Riparian trees at the water source in Merbaun Village, West Amarasi Distric (Chatarina, et al., 2024). Research findings show that there are 15 tree species including 11 native species and 4 foreign species findings from the study revealed that the Kaki Dian heart garden has 266 trees divided into 70 species and 28 families. The small variation in tree species in the mountains of Pasikh Nunang Village occurs because the research location is in a forest area that has mostly been converted into plantations, so that its sustainability is starting to be threatened. Meanwhile, the area studied is located at an altitude of between 450 and 1000 meters above sea level. Furthermore, the percentage of the number of individuals in each type in each family.

Based on the Figure 1, it can be explained that the largest group of individuals is seen in the Moraceae family with a percentage of 22%, while the Lauraceae and Meliaceae families are each found with a number of 21%, making it the second largest group. On the other hand, the smallest number of individuals is found in the Sapotaceae family, which only reaches 1%. This group of plants is a family that is very often found in tropical rainforests, especially in Indonesia. Phyllanthaceae can be found in various parts of the world, especially in tropical areas. There are more than 1,200 species (Challen, 2015).

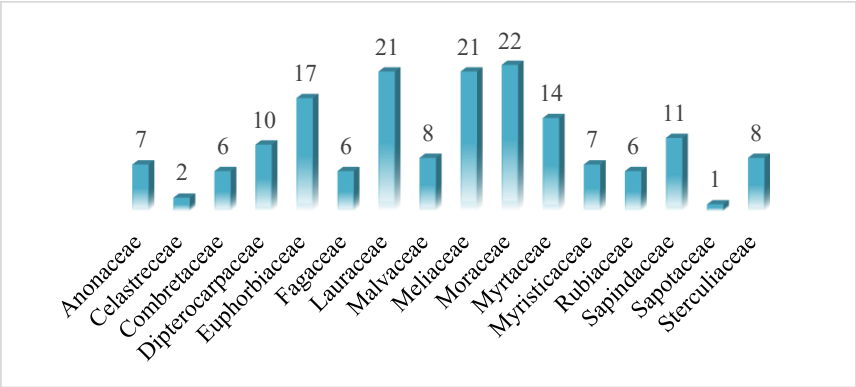

Figure 1 Percentage of the Number of Individual Trees in Each Family in the Pasikh Nunang Village Forest, Southeast Aceh

Table 2. Area of Basic Areas of Trees in Pasekh Nunang Village Forest, Southeast Aceh Regency

Family	Species Name	Number of Individuals	LBD Tree (cm)
Anonaceae	*Picrasma javanica*	7	38,34
Celastreceae	*Lophopetalum javanicum*	2	3,13
Combretaceae	*Terminalia catappa*	6	28,17
Dipterocarpaceae	*Parashorea lucida*	6	28,17
Euphorbiaceae	*Baccaurea deflexa*	4	12,52
	Mallotus sp.	5	19,56
	Macaranga tanarius	9	63,38
Fagaceae	*Quercus sp.*	3	7,04
	Castanopsis sp.	3	7,04
	Lithocarpus sp.	3	7,04
Lauraceae	*Eusideroxylon zwargeri*	21	345,08
Malvaceae	*Pterospermum javanicum*	5	19,56
	Mastixia trichotoma	3	7,04
Meliaceae	*Canarium denticulatum*	7	38,34
Moraceae	*Arthocarpus nitidus*	1	0,78
	Aglaia racemosa	4	12,52
	Aglaia racemosa	4	12,52
	Antiaris toxicaria	5	19,56
	Arthocarpus sp.	3	7,04
	Dalbergia latifolia	2	3,13
	Arthocarpus elasticus	8	50,08
	Ficus sp.	4	12,52
Myrtaceae	*Bichotan charcoal*	14	153,37
Myristicaceae	*Corymbia opaca*	7	38,34
Rubiaceae	*Canarium odoratum*	6	28,17
Sapindaceae	*Pometia pinnata*	11	94,68
Sapotaceae	*Payena lucida*	1	0,78
Sterculiaceae	*Abroma sp.*	8	50,08
Total LBD Amount			1108,02

Based on the Table 2, it can be explained that the basal area (LBD) of the tallest tree in the Pasikh Nunang Village forest was recorded in the Eusideroxylon zwargeni species with a value of 345.08 cm2, followed by Bichotan charcoal which has an LBD of 153.37 cm2, and Macaranga tanarius which reaches 63.38 cm2. The lowest LBD values are found in the Arthocarpus nitidus and Payena lucida species, each of which is 0.78 cm2. The high LBD figures in Eusideroxylon zwargeni, Bichotan charcoal, and Macaranga tanarius are due to the large population, namely 21, 14, and 9 individuals in the natural forest, with an

altitude of the research location between 400-500 m above sea level. The percentage comparison of the total LBD values of trees in the seven largest families in the research area.

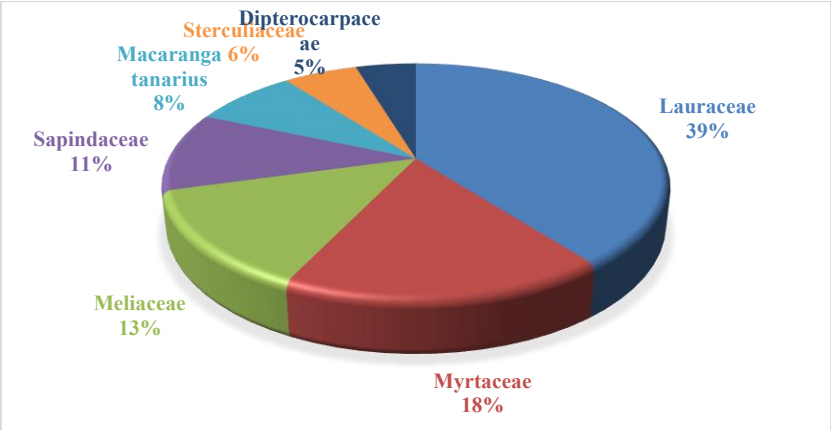

Figure 2. Comparison of LBD (%) of trees of the 7 largest families in the Pasikh Nunang Village Forest, Southeast Aceh

From Figure 2. It can be seen that the Lauraceae family has the maximum basal area among the 7 largest families, which is 39%, while the Diterocarpaceae family has a minimum basal area of 5%. The high basal area in the Lauraceae family is due to the large number of tree species and the larger stem diameter of various tree species at the research location. This indicates that the reliability of the forest in absorbing nutrients and adapting to the growth location of a species is quite good, so that the types of plants are not focused on just one species. With the diversity of all types of vegetation in the forest, this provides an opportunity for vegetation to remain in the forest structure (Juniarti et al, 2017).

The analysis of species richness conducted at the research location in the Pasikh Nunang Village forest area showed varying results at each location. The differences in these values indicate the character and fertility of the species richness in its environment (Kusmana, 2022).

Table 3. KR (%), FR (%), DR (%) and INP (%) Values of Tree Types in the Pasikh Nunang Village Forest Area

Nama Spesies	KR	FR	DR	INP
Corymbia opaca	4,32	3,45	3,46	11,23
Eusideroxylon zwargeri	12,96	9,20	31,14	53,30
Bichotan charcoal	8,64	6,90	13,84	29,38
Pometia pinnata	6,79	8,05	8,55	23,38
Picrasma javanica	4,32	4,60	3,46	12,38
Pterospermum javanicum	3,09	2,30	1,77	7,15
Quercus sp.	1,85	3,45	0,64	5,94
Arthocarpus nitidus	0,62	1,15	0,07	1,84
Baccaurea deflexa	2,47	3,45	1,13	7,05
Mastixia trichotoma	1,85	2,30	0,64	4,79
Aglaia racemose	2,47	2,30	1,13	5,90
Mallotus sp.	3,09	3,45	1,77	8,30
Payena lucida	0,62	1,15	0,07	1,84
Castanopsis sp.	1,85	2,30	0,64	4,79
Parashorea lucida	3,70	3,45	2,54	9,69
Aglaia racemosa	2,47	3,45	1,13	7,05
Canarium denticulatum	4,32	3,45	3,46	11,23
Antiaris toxicaria	3,09	2,30	1,77	7,15
Arthocarpus sp.	1,85	2,30	0,64	4,79
Dalbergia latifolia	1,23	1,15	0,28	2,67

Nama Spesies	KR	FR	DR	INP
Arthocarpus elasticus	4,94	4,60	4,52	14,06
Ficus sp.	2,47	2,30	1,13	5,90
Lophopetalum javanicum	1,23	2,30	0,28	3,82
Terminalia catappa	3,70	3,45	2,54	9,69
Canarium odoratum	3,70	4,60	2,54	10,84
Macaranga tanarius	5,56	4,60	5,72	15,87
Lithocarpus sp.	1,85	2,30	0,64	4,79
Abroma sp.	4,94	5,75	4,52	15,21
Total Number of Individuals	100,00	100,00	100,00	300,00

Description:
KR = Relative Density
FR = Relative Frequency
DR = Relative Dominance
INP = Importance Value Index (Zakia et al., 2024)

From the Table 3, it can be seen that the Relative Density value for trees in the Pasikh Nunang Village forest is in the range of 0.62%-12.96%, the Relative Frequency value ranges from 1.15%-9.20%, the Relative Dominance value varies from 0.07%-31.14%, and the Importance Value Index value is between 1.84%-53.30%. The Eusideroxylon zwargeri species showed the highest KR, FR, DR, and INP values, while the two species with the lowest values were Arthocarpus nitidus and Payena lucida. The high KR value of this tree reflects the success in seed germination, and the many types of trees found at the research location at an altitude of 450-1,000 m above sea level.

Table 4 Tree Diversity Index (H') in Pasikh Nunang Village Forest, Southeast Aceh Regency

Spesies Name	Amount	Pi	Ln Pi	Pi Ln Pi	H'
Corymbia opaca	7	0,04	-3,14	-0,14	3,12
Eusideroxylon zwargeri	21	0,13	-2,04	-0,26	
Bichotan charcoal	14	0,09	-2,45	-0,21	
Pometia pinnata	11	0,07	-2,69	-0,18	
Picrasma javanica	7	0,04	-3,14	-0,14	
Pterospermum javanicum	5	0,03	-3,48	-0,11	
Quercus sp.	3	0,02	-3,99	-0,07	
Arthocarpus nitidus	1	0,01	-5,09	-0,03	
Baccaurea deflexa	4	0,02	-3,70	-0,09	
Mastixia trichotoma	3	0,02	-3,99	-0,07	
Aglaia racemosa	4	0,02	-3,70	-0,09	
Mallotus sp.	5	0,03	-3,48	-0,11	
Payena lucida	1	0,01	-5,09	-0,03	
Castanopsis sp.	3	0,02	-3,99	-0,07	
Parashorea lucida	6	0,04	-3,30	-0,12	
Aglaia racemosa	4	0,02	-3,70	-0,09	
Canarium denticulatum	7	0,04	-3,14	-0,14	
Antiaris toxicaria	5	0,03	-3,48	-0,11	
Arthocarpus sp.	3	0,02	-3,99	-0,07	
Dalbergia latifolia	2	0,01	-4,39	-0,05	
Arthocarpus elasticus	8	0,05	-3,01	-0,15	
Ficus sp.	4	0,02	-3,70	-0,09	
Lophopetalum javanicum	2	0,01	-4,39	-0,05	
Terminalia catappa	6	0,04	-3,30	-0,12	

Spesies Name	Amount	Pi	Ln Pi	Pi Ln Pi	H'
Canarium odoratum	6	0,04	-3,30	-0,12	
Macaranga tanarius	9	0,06	-2,89	-0,16	
Lithocarpus sp.	3	0,02	-3,99	-0,07	
Abroma sp.	8	0,05	-3,01	-0,15	
Amount	162	1,00	-99,55	-3,12	

From Table 4. which has been presented, it can be seen that in the Pasikh Nunang forest, the Diversity Index (H') for trees has a value of 3.12, which is included in the high category.

Table 5. Physical Environmental Factor Data in Pasikh Nunang Village Forest, Southeast Aceh Regency

Desa Pasikh Nunang	Air temperature (C)	Soil pH	Light Intensity (Lux)	Air Humidity (%)
Hutan	25	6,5	800	92

Based on Table 5 above, it is known that the light level shows normal or ideal results, as well as temperature and humidity whose values vary. The light level in the Pasikh Nunang Village forest increases with increasing temperature. High light levels occur due to the presence of dead trees or former logging that creates open spaces. These open spaces appear due to illegal logging and human-caused factors.

Table 6. Biomass and Carbon Stored in the Pasikh Nunang Village Forest, Southeast Aceh Distric

Species Name	Amount	Diameter (cm)	Carbon Biomass (tons)
Corymbia opaca	7	525,0	13,71
Eusideroxylon zwargeri	21	1465,0	16,31
Bichotan charcoal	14	926,0	15,15
Pometia pinnata	11	721,0	14,52
Picrasma javanica	7	522,0	13,70
Pterospermum javanicum	5	387,0	12,94
Quercus sp.	3	202,0	11,30
Arthocarpus nitidus	1	67,0	8,50
Baccaurea deflexa	4	309,0	12,37
Mastixia trichotoma	3	209,0	11,38
Aglaia racemose	4	251,3	11,85
Mallotus sp.	5	329,6	12,53
Payena lucida	1	77,0	8,86
Castanopsis sp.	3	223,0	11,55
Parashorea lucida	6	511,0	13,64
Aglaia racemose	4	325,0	12,50
Canarium denticulatum	7	517,0	13,67
Antiaris toxicaria	5	366,0	12,80
Arthocarpus sp.	3	588,0	14,00
Dalbergia latifolia	2	155,0	10,63
Arthocarpus elasticus	8	507,0	13,62
Ficus sp.	4	289,0	12,20
Lophopetalum javanicum	2	164,0	10,77
Terminalia catappa	6	435,0	13,24
Canarium odoratum	6	372,0	12,84
Macaranga tanarius	9	660,0	14,29
Lithocarpus sp.	3	216,0	11,47
Abroma sp.	8	564,0	13,89
Amout	162	11882,9	354,23

The carbon storage value is determined by measuring tree biomass. The amount of carbon stored is 50% of the measured biomass. Tree biomass (dry weight) is calculated using an allometric equation based on measurements of stem diameter at breast height (DBH). Data on biomass and stored carbon.

The results of the analysis of the Table 6 above show that carbon biomass and stored carbon have quite high values in the mountains of Pasikh Nunang Village, Southeast Aceh Regency. The types of trees with the highest carbon biomass are Eusideroxylon zwageri with 16.13 tons/ha and Bichotan charcoal which each have 15.15 tons/ha. Meanwhile, the type of tree with the lowest carbon biomass is Arthocarpus nitidus which has 8.50 tons/ha. The increase in CO_2 levels in the atmosphere needs to be balanced with the amount of carbon that can be absorbed to reduce global warming. The total amount of carbon stored in trees.

It can be seen that in the mountainous forest of Pasikh Nunang Village, there is a total carbon storage of 354.23 tons/ha. The high value of carbon storage in the mountainous forest is caused by the wider diameter of the trees and the large number of individual trees in the research location. Total carbon availability in the Mount Sirimau protected forest is 418.98 tons/ha, which comes from tree carbon reserves, 402.25 tons/ha (96%), and understory plants 16.69 tons/ha (4%) (Riry et al., 2022).

CONCLUSION

From the research that has been conducted on the analysis of tree species in the forest of Pasikh Nunang Village, Lawe Alas District, Southeast Aceh Regency, the condition of tree vegetation in the research area is in the good category, with 28 tree species from 16 families recorded, and a total of 162 individuals. The of Pasikh Nunang Village, Southeast Aceh Regency the Diversity Index (H') for trees has a value of 3.12, which is included in the high category and The total carbon stored in tree species at the research location is quite large, reaching 354.23 tons/ha.

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