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Monitoring Forest Health Based on Species Diversity Parameters Around Way Kalam Waterfall Tourism Area

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ABSTRACT

This study aims to assess forest health based on species diversity indicators around the Way Kalam Waterfall tourism area in Penengahan, South Lampung. The FHM method was applied using four cluster plots to evaluate the vegetation condition through species diversity, composition, and tree community structure measurements. The results showed that the Shannon-Wiener diversity index (H') in all clusters was categorized as low, indicating a homogeneous vegetation structure and dominance of several species. Despite the low diversity values, the final forest health scores (NKH) revealed that three clusters were classified as "Good," while one cluster fell into the "Poor" category due to higher ecological pressure and reduced species variation. These findings demonstrate that although the forest ecosystem is still functioning, it is experiencing a decline in biodiversity, which may affect long-term ecological stability. Therefore, biodiversity indicators remain essential for detecting early ecological disturbances, particularly in tourism areas that are vulnerable to human activities. Effective management strategies, such as vegetation enrichment, controlled tourism activities, and regular forest health monitoring, are necessary to maintain ecological resilience and support sustainable forest conservation.

INTRODUCTION

Indonesia's forests, which are officially recognized by the Ministry of Environment and Forestry as eighth in terms of world area, had an area of 95.6 million hectares in 2020, which means they covered 50.9% of the total land area. From this data, it can be concluded that forest areas in Indonesia are still larger than non-forest areas (Rohmaningtyas, 2022). Forest areas play an important role in human life (Nakita & Najicha, 2022). The forest around the Way Kalam waterfall tourist location is one of the forests located in South Lampung Regency, this forest plays

an important role as an ecosystem that has abundant biodiversity and maintains environmental balance.

Uncontrolled tourism activities such as camping, the construction of tourist facilities, and excessive numbers of visitors can cause tree damage, soil erosion, and reduced biodiversity (Fernando et al., 2022). One of the problems that arise due to forest degradation is the destruction of trees due to various environmental factors and human activities, such as land-use change and unsustainable management pressures. This damage has an impact on the overall health of the forest (Safe'i, Maulana, et al., 2022). Recent research shows that the higher the intensity of tourist visits, the greater the decrease in the ability of plants to regrow, as well as the pressure on the environment around tourist routes. In addition, changes in land use and the construction of tourist facilities also cause changes in the surrounding vegetation and accelerate the similarity of plant types in forests that are not too old (Damiti et al., 2025).

The dynamics of forest ecosystems are greatly influenced by changes in tree species diversity and vitality due to intensive human activities. Practices such as selective logging, and the destruction and decline of species diversity led to significant forest destruction, thereby reducing forest resilience to degradation. These changes have the potential to reduce the sustainability of overall ecosystem function in tropical community areas (Safe'i, Puspita, et al., 2022). Recent research shows that changes in plant shape due to human activities can damage the ecological functions of forests, such as the ability of forests to grow on their own, absorb carbon, and withstand unstable environmental conditions. This condition shows the importance of conducting forest health assessments based on biodiversity indicators to understand ecological pressures more precisely (Wandik et al., 2025).

The Tree Health Assessment aims to review the current situation, changes that have occurred, as well as long-term patterns in forest ecosystems. Forest Health Monitoring uses ecological signs to collect data and information on the health conditions of conservation forests to ensure the quality of the forest itself (Safei et al., 2021). One of the parameters of forest health indicators is species diversity. Species diversity indicators in forest health assessments show the variety of species that exist in a forest ecosystem. The level of abundant species diversity usually describes good ecosystem conditions and has the ability to adapt to environmental changes or disturbances from the outside (Sanjaya et al., 2023).

This study aims to analyze forest health based on the parameters of species diversity around Way Kalam Waterfall, Penengahan, South Lampung. A biodiversity-based approach is used because changes in the biotic ecological component are often an early indicator of disturbances, especially in tourist areas that are vulnerable to stress due to visitor activities and facility development. The results of the research are expected to provide an overview of forest ecology and become the basis for planning for sustainable management strategies and conservation efforts.

METHODS

The tools used in the collection of research data include a roll meter 50m meter, phiband, camera, calculator, ruler, GPS (Global Positioning System), stationery. The object of research in this study is around the tourist location of Way Kalam Waterfall. This research was conducted in June 2025. The research location is in Way Kalam Village, Penengahan District, South Lampung Regency. Figure 1 shows a map of the research location.

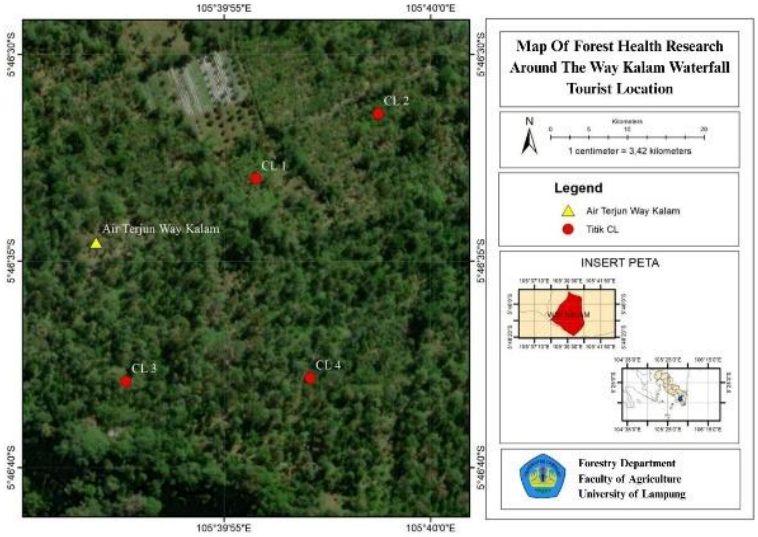

Figure 1. Map Research Locations Around Way Kalam Waterfall Tourist Locations

The determination of clusters in a forest serves to determine the location to be chosen as a cluster plot. The determination of plot clusters in this study was carried out with justification, namely considering management aspects and observation locations. Based on the manager, the area is divided into two main groups, namely those managed by the Village Forest Management Institution (LPHD) and those managed directly by the community. Furthermore, the areas managed by LPHD are divided into two clusters, namely in protected forest areas and in tourist areas. Meanwhile, community-managed areas are also divided into two clusters, namely community forests and areas around tourist sites. On the basis of this division, the number of plot clusters determined in this study is as many as four plot clusters.

The use of plot clusters is to collect sample data that can present the entire area of land observed, the criteria for FHM plot clusters are as follows: Each cluster of plots consists of 4 sample plots that are circular in shape. The plot cluster has a circular annular plot with a radius of 17.95 meters. The central point of plot 1 becomes the center of the entire sample plot in one cluster. The center point of plot 2 is located in the direction of 0° or 360° from the center point of plot 1. The center point of plot 3 is located in a direction of 120° from the center point of plot 1. The center point of plot 4 is located in a direction of 240° from the center point of plot 1. The distance between each sample plot and the center point of the cluster (Plot 1) is 36.6 meters. The plot cluster consists of 4 annular plots, 4 subplots, and 4 microplots. Each plot cluster has 3

soil sampling sampling points, which are located at the distance between plot 1 and the other three sample plots. Picture of the plot cluster in Figure 2

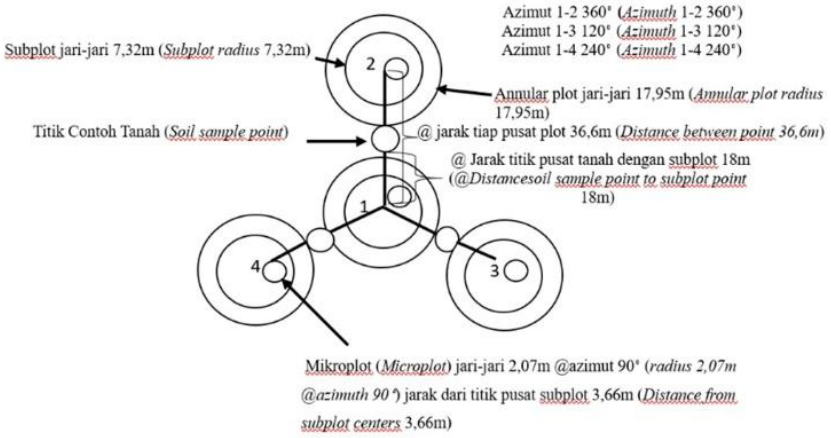

Figure 2. FHM Plot Cluster Design

Data analysis used in this study consist of calculation of species diversity and calculation of the final value of forest health. The calculation of the species diversity index uses the Shannon-Wiener Index formula which includes

$$H' = \sum_{i=1}^{S} PiInPi$$

Description:
H' = Shannon Wiener Index Pi = ni/N
Pi = Number of Individuals i- i
ni = Number of individuals type to - i
N = Number of individuals of all types

If the H' value found is less than 1, then the vegetation diversity shows low instability. If the value of H' is between 1 and 2, then the forest vegetation component can be considered stable. Meanwhile, if the value of H' is more than 1, then the diversity of vegetation is categorized as very stable. Meanwhile to calculate the final value of forest health is obtained by the following formula:

$$NKH = \sum(NT \times NS)$$

Description:
NKH = Final value of forest health conditions
NT = Parameter weighted values of each ecological indicator of forest health
NS = The parameter score value of each ecological indicator of forest health.

RESULTS AND DISCUSSION

The results found show several types of trees with their number in each cluster, which can be seen in Table 1.

Table 1. Diversity of Tree Types in Each Cluster

Location	Tree Type	Latin Names	Quantity
CL1	Cengkeh	*Syzygium aromaticum*	3
	Angsana	*Pterocarpus indicus*	2
	Mindi	*Melia azedarach*	20
	Durian	*Durio zibethinus*	8
	Mangga	*Mangifera indica*	1
	Alpukat	*Persea americana*	12
	Petai	*Parkia speciosa*	3
	Jambu Jamaika	*Sysygium malaccense*	4
	Bayur	*Pterospermum javanicum*	1
	Jengkol	*Archidendron pauciflorum*	12
	Medang	*Phoebe*	3
	Sobsie	*Maesopsi eminii*	4
	Klandri	*Bridelia monoica*	1
	Salam	*Syzygium polyantum*	1
	Dadap	*Erythrina variegata*	3
CL2	Karet	*Hevea brasilliensis*	21
	Jambu Jamaika	*Syzygium malaccenses*	2
	Mindi	*Melia azedarach*	3
	Durian	*Durio zibethinus*	9
	Alpukat	*Persea americana*	7
	Jengkol	*Archidendron pauciflorum*	8
	Randu	*Ceiba petandra*	4
	Asam Kandis	*Gramenia xanthoehymus*	1
	Kopi	*Coffea arabica*	1
	Petai Cina	*Leucaena leuchocepala*	1
	Medang	*Phoebe*	1
	Seriwil Kutil	*Pterocimbium tinctorium*	1
	Melinjo	*Gnetum gnemon*	1
	Petai	*Parkia speciosa*	5
CL3	Melinjo	*Gnetum gnemon*	26
	Durian	*Durio zibethinus*	28
	Alpukat	*Persea americana*	5
	Jengkol	*Archidendron pauciflorum*	9
	Pupuk	*Tithonia diversifolia*	7
	Cengkeh	*Syzygium aromaticum*	9
	Mangga	*Mangifera indica*	2
	Petai	*Parkia speciosa*	4
	Kopi	*Coffea arabica*	1
	Tabu	*Handroanthus chrysotrichus*	1
	Asam Kandis	*Graneima xanthoehymus*	1
	Langsat	*Lansium domesticum*	1
CL4	Durian	*Durio zibethinus*	23
	Jengkol	*Archidendron pauciflorum*	5
	Nangka	*Artocarpus heterophyllus*	1
	Angsana	*Pterocarpus indicus*	5
	Alpukat	*Persea americana*	10
	Medang	*Phoebe*	1
	Kopi	*Coffea arabica*	2

Location	Tree Type	Latin Names	Quantity
	Mindi	*Melia azedarach*	2
	Cengkeh	*Syzygium aromaticum*	8
	Petai	*Parkia speciosa*	7
	Pupuk	*Tithonia diversifolia*	1
	Jeruk	*Citrus nabillis*	1
	Dadap	*Erythrina variegata*	2
	Melinjo	*Gnetum gnemon*	12
	Mara	*Macaranga tanarius*	1
QUANTITY			318

Table 2. Parameter Assessment of Species Diversity Indicators

Location/CL	H' Value
CL1	0.1738
CL2	0.1711
CL3	0.1726
CL4	0.1740

Table 3. Forest Health End Value

Location	NKH	Category
CL1	1.35	Good
CL2	0.15	Bad
CL3	0.90	Good
CL4	1.50	Good
Average	0.98	Good

The variation in species composition in each cluster reflects differences in the level of pressure and management of the ecosystem, as well as the dominance of one or two specific species that exhibit a homogeneous vegetation structure. This has been discussed in several ecological studies. Homogeneous vegetation structures usually appear in areas with intense human intervention, such as mixed gardens or community cultivation areas. Tree species diversity is under pressure due to various types of damage identified by human activities. This damage threatens the composition of native species and ecosystem function, which requires monitoring interventions to maintain the sustainability of tree biodiversity in the region (Damayanti et al., 2024). This situation can lead to a decrease in species diversity, which has an impact on decreasing ecosystem stability. Low diversity conditions also make forests more susceptible to disturbances such as pest attacks, diseases, and microclimate change, as the lack of variation in plant composition reduces the resilience of ecosystems to these stresses. In contrast, clusters with a more diverse distribution of species show better ecological conditions, as interactions between types are balanced, which supports optimal forest ecological function (Maulidia et al., 2025).

Species diversity is a wide variety of living things that live in an ecosystem, including plants and animals. This diversity is important because it helps maintain the health of the environment and ensures that the ecosystem remains stable and sustainable. If the diversity of species is high, then the ecosystem is usually strong in the face of changes or pressures from the surrounding

environment (Safe'i, Darmawan, et al., 2021). In addition, these various types of organisms also have important roles such as helping the pollination process, controlling pests naturally, and accelerating the nutrient cycle in nature. Each species has a unique role in the food chain and maintains the balance of the ecosystem. So, if one type of organism is lost, it can disrupt the structure and function of the ecosystem as a whole. Therefore, maintaining species diversity is very important in efforts to protect the environment and manage natural resources appropriately and sustainably (Latumahina et al., 2024).

High species diversity plays a very important role in increasing the resilience of forest ecosystems to various disturbances. Ecosystems with a wider variety of species tend to exhibit more stable ecological functions, including in terms of light use efficiency, nutrient absorption, and resilience to microclimate change. Recent research reveals that forests with low diversity are more susceptible to structural changes when faced with disturbances such as drought or the entry of foreign species These findings are in line with the results of this study which suggests that vegetation uniformity in some clusters can degrade the ability of ecosystems to cope with environmental pressures. The species diversity index (H') values in each cluster indicated that the tree community structure across the study sites tended to have low diversity. Although there is variation in the number of individuals and species in each cluster, low diversity values indicate that vegetation communities are dominated by certain species and therefore the distribution of species is uneven. The low diversity of this type is an important indicator that the ecosystem is still under ecological pressure that needs to be considered in its management (Safe'i et al., 2024).

The low value of diversity in all clusters reflects a homogeneous community structure and indicates the low regeneration of some local species that play an important role in maintaining ecosystem stability. When a vegetation community is dominated by one particular species, the ecosystem's resistance to environmental changes such as drought, pest attacks, and diseases tends to decrease. The variation in the diversity index values found showed that each cluster had a different level of forest health. Clusters with higher index values indicate a more stable ecosystem and are able to withstand disturbances. High forest health indicator values are usually related to optimal ecosystem function, such as pollination, nutrient cycling and resistance to pests or diseases. Therefore, this index is the main benchmark in the evaluation of forest health (Safe'i, Ardiansyah, et al., 2021).

Differences in forest health categories among clusters showed variations in ecological stress levels across the study area. The clusters that fall into the "Good" category, namely cluster 1, cluster 3 and cluster 4, show that although species diversity is low, other factors such as soil conditions, tree vitality, and individual damage levels are still within acceptable levels. A high H' value indicates a stable community and a healthy ecosystem, while a low H' value indicates dominance by some specific species as well as low ecological stability.

The cluster that is included in the "Bad" category, namely cluster 2, shows higher pressure on the ecosystem, both in the form of disturbances from human activities, the intensity of tree use, and the homogenization of vegetation due to the dominance of certain types of plants. This dominance often occurs in areas with more intensive tourism or community management activities, where certain types are grown for economic purposes. This is in accordance with what was stated by (Malik et al., 2020). That is, low diversity in an area can be influenced by human activities, uneven management, or environmental conditions that do not support the growth of various other types.

Overall, the combination of the results of the species diversity index and the NKH value provides a more complete picture of the health condition of the forest around Way Kalam Waterfall. The average value of NKHs in the "Good" category indicates that the ecosystem still has the ability to maintain its ecological function, but the low value of species diversity indicates that there are ecological risks that need attention in long-term management. Improvement efforts can be made through increasing the diversity of species, regulating tourist routes, controlling visitor activities, and rehabilitating local vegetation.

CONCLUSION

The conclusion of this study is that the value of the species diversity index (H') in all clusters is relatively low, indicating a homogeneous vegetation structure and the dominance of several certain species, so that the potential for ecosystem stability has the potential to decrease. However, the assessment of the final forest health value (HCN) showed that three clusters were in the Good category, while one cluster was in the Poor category due to high ecological pressure. Overall, the average NKH is categorized as Good, which shows that the ecosystem is still able to carry out its ecological functions despite indications of biodiversity decline that need attention.

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