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Monitoring Vegetation as Habitat (*Paradisaea minor jobiensis* Rothschild, 1879) in the Period 2024, 2018, and 2024 to Support Birdwatching Ecotourism in Barawai Yapen Islands Regency Papua

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Abstract: Imbowiari Forest in Barawai Village, Yapen, Papua, has complex flora and fauna biodiversity, including as a habitat for Paradisaea minor jobiensis. In Papua, especially the Yapen Islands Regency, endemic species such as *Paradisaea minor jobiensis* are the main attraction for tourists. Managed by the community through local wisdom and the Dorey Jaya group, this area has the potential to be developed as birdwatching ecotourism. However, it has not been widely popular with tourists. This study aims to analyze changes in the vegetation of the bird's habitat for three periods (2014, 2018, and 2024) and provide recommendations for ecotourism management in Barawai. Vegetation structure and composition data were collected using the grid line method and analyzed using PAST software. The results showed an increase in the number of species at all vegetation levels, especially seedlings (21 species in 2014 to 72 in 2024), saplings (27 to 64), poles (26 to 76), and trees (41 to 96). The number of individuals also increased significantly, especially on saplings and poles. The diversity index also increased, especially at the tree level (2.78 to 4.07). This study indicates an increase in overall vegetation, with recommendations for optimizing ecotourism management based on biodiversity and local wisdom.

Keywords: Barawai; Birdwatching; Monitoring; *Paradisaea minor jobiensis*; Vegetation

Introduction

Birdwatching ecotourism has become one of the rapidly growing tourism activities in various regions with high biodiversity (Ren et al., 2022; De Zoysa, 2022; Müllner et al., 2004). In Papua, especially the Yapen Islands Regency, endemic species such as *Paradisaea minor jobiensis* are the main attraction for tourists (Waroy et al., 2020; Rozi et al., 2024). This bird not only has aesthetic beauty but also plays an important role in the tropical forest ecosystem as an indicator of environmental health (Khosravi Mashizi & Sharafatmandrad, 2024; Cooper et al., 2016; Brockerhoff et al., 2017). Efforts to preserve the natural habitat of the Cenderawasih bird are a crucial aspect in maintaining the sustainability of their population while supporting

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the development of sustainable ecotourism (Sayuti, 2023; Suana et al., 2020). The habitat of *Paradisaea minor jobiensis* in Barawai Village, Raimbawi District, Yapen Islands, is mainly located in the Imbowiari forest, which is rich in plant diversity (Wambrauw et al., 2023; Wazaraka et al., 2019). The existing vegetation functions as a perch, nesting place, and food source for the Cenderawasih bird. Therefore, monitoring the structure and composition of vegetation from 2014, 2018, to 2024 is important to understand the dynamics of habitat change, as well as to formulate appropriate conservation strategies to support the development of birdwatching ecotourism in this region.

Vegetation monitoring includes observations of variations in tree species, epiphytic plants such as Asplenium nidus, and changes in vegetation strata composition throughout the period (Rodriguez et al., 2024). This aims to identify ecological factors that affect the quality of the Cenderawasih bird's habitat. Climate change, human activities, and other natural factors can cause changes in the bird's natural habitat, so a holistic approach to environmental management is needed to ensure that the ecosystem continues to support the sustainability of this endemic animal. In addition, birdwatching ecotourism in Barawai has great potential to improve the economic welfare of local communities while maintaining the balance of nature. Ecotourism programs that focus on biodiversity, especially birds of paradise, can be an alternative source of income for local communities through guiding activities, accommodation, and local products (Uddin et al., 2021).

Therefore, the results of this vegetation monitoring will be the basis for developing environmentally friendly and sustainable ecotourism management strategies. Thus, this study aims to analyze changes in the vegetation of the *Paradisaea minor jobiensis* habitat during three time periods 2014, 2018, and 2024, and provide recommendations for the management of ecotourism areas in Barawai Village. This research is expected to provide a significant contribution to the conservation of Cenderawasih birds and the development of conservation-based ecotourism in Papua.

Method

The equipment and materials used in this study were herbarium equipment, a digital camera, GPS, a raffia rope, a meter roll (50 m), plastic bags (sample containers), cutting scissors, and 70% alcohol. The population in this study were all plants found in the forest area as the habitat of *Paradisaea minor jobiensis*, while the samples were plants found in the observation plot. Data collection used a combination of gridded line paths on sample units in the form of 100 m long paths which can be shown in Figure 1. In addition to these methods, data collection from several previous studies can be done by reviewing secondary reference sources or various previous studies in 2014 and 2028.

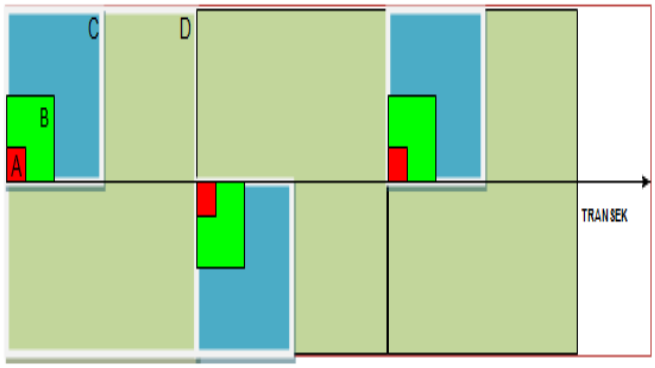


Figure 1. Scheme of transect placement and measurement plots

Description:
A = Plot for seedlings, epiphytes, lianas, and parasites (2 x 2 m^2)
B = Stake (5 x 5 m^2);
C = Pole (10 x 10 m^2);
D = Tree (20 x 20 m^2)

To analyze the data in this study, PAST software was used to view or measure the dominance, Simpson, Shannon, evenness, Brillouin, men think, margalef, and equitability indices:

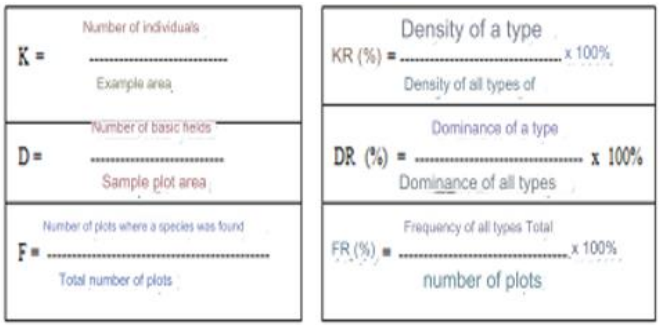


Figure 2. Measuring dominance, Simpson, Shannon, evenness, Brillouin, men think, margalef, and equitability indices

To calculate the Shannon-Wiener Diversity Index, the following formula is used:

$$(H') = -\Sigma [p_i \text{ Log } p_i] \quad \text{Where } p_i = n_i / N \qquad (1)$$

Description:
H' = Shannon-Wiener Diversity Index
ni = Density of the i-th species
N = Total number of species found
The assessment categories for species diversity are:

H' < 1 : Low diversity, low distribution, low community stability.
1 <H'<3 : Medium diversity, medium distribution, medium community stability.
H '>3 : High diversity, high distribution, high community stability.

Result and Discussion

Vegetation Analysis in Imbowiari Forest Area in 2014, 2018, and 2024
Vegetation Analysis in Imbowiari Forest Area in 2014
Vegetation Analysis at Seedling Level

Figure 1 shows that there are 21 species consisting of 68 individuals. These species have varying numbers of individuals. Species such as Syzygium sp have a more dominant number of individuals than others, reaching 10. This may indicate that this species dominates in the area, while other species have a more limited population. The presence of 21 species with 68 individuals shows a fairly diverse community, but this diversity is not evenly distributed, because there are dominant species that control most of the population. This is under the pattern often found in natural communities where some species dominate while others have smaller populations. Other species have fewer individuals, which may indicate vulnerability to environmental change or higher habitat specialization. This is in line with the statements (She et al., 2023; Jia et al., 2022; Meng et al., 2024), that dominant species can influence community structure and how individual variation among species affects ecosystem stability.

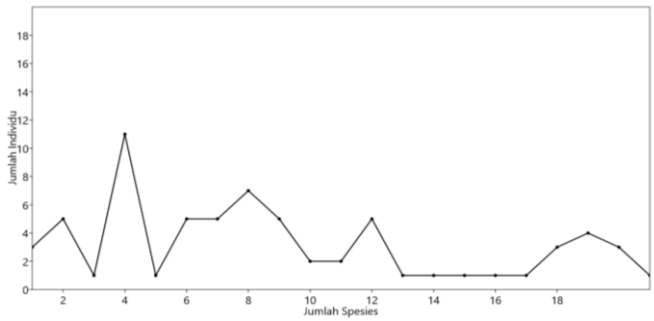
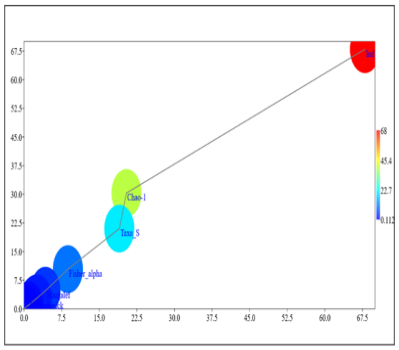


Figure 2. Number of species and individuals at seedling level

The distribution of individuals among species is uneven, which is common in natural ecosystems. This variation may indicate differences in the species' ability to adapt to certain environments, interactions between species, or other environmental factors such as resource availability. The Syzygium sp. species appears to dominate the community because it has the highest number of individuals, reaching 10. This dominance may be caused by various factors such as the ability to compete for resources, the ability to adapt to environmental conditions, or a more efficient reproductive cycle compared to other species. Correia et al. (2023), and Listmann et al. (2020) explains that Syzygium sp. can dominate a community due to competitive interactions or ecological adaptation.



	A	Lower	Upper
Taxa_S	21	19	21
Individuals	68	68	68
Dominance_D	0.07656	0.06704	0.1112
Simpson_1-D	0.9234	0.8888	0.933
Shannon_H	2.772	2.544	2.851
Evenness_e^H/S	0.7614	0.643	0.8301
Brillouin	2.383	2.192	2.451
Menhinick	2.547	2.304	2.547
Margalef	4.74	4.266	4.74
Equitability_J	0.9104	0.8532	0.9383
Fisher_alpha	10.39	8.749	10.39
Berger-Parker	0.1618	0.1176	0.25
Chao-1	30.33	20.43	39.33

Figure 3. Number of species, dominance index, simpson index, H', evennes, brillouin, menhinick, margalef, equitability, fisher_alpha, berger-parker, chao-1 at seedling level

The research data in Figure 2 shows that the dominance value is 0.076 with a range between 0.67-0.11. The dominance index measures the dominance of a particular species in a community. A low value (0.07) indicates that no one species dominates excessively; the distribution is relatively uniform. Meanwhile, the species diversity obtained from Simpson's analysis is 0.92 with a range between 0.88-0.93. The value is close to 1 and indicates high diversity, which means that individuals are spread across various species and are not concentrated in only a few species. Meanwhile, the diversity value with Shannon shows a moderate to high value (2.77) which interprets that the higher the value, the higher the community diversity. The evenness value is 0.76 with a range of 0.64-0.83. A value approaching 1 indicates a more even distribution although some species may be slightly more dominant. Species richness is at a value of 4.74 or in the range of 4.26-4.74 which indicates a community with relatively high species richness. These data indicate that the analyzed community has a relatively high level of species diversity, with a fairly even distribution of individuals among species. No species is too dominant, and the diversity in this community reflects a healthy and stable community.

Sapling Level Vegetation Analysis

These sapling-level vegetation data show the composition and structure of tree species at the research site. The research data shows that there are 86 individuals of various tree species at the sapling level (young plants that are taller than seedlings and weanings but have not reached the size of mature trees).

There are 27 different species, which shows quite good diversity for vegetation at the sapling level. This diversity can be further assessed using diversity indices such as Shannon-Wiener (H') or Simpson (D), but at a glance, the number of species represented with various numbers of individuals indicates good diversity potential.

Glochidion macrocarpum Bl is the species with the largest number of individuals (20 individuals), indicating that this species dominates the vegetation community at the sapling level in the area. The dominance of this species could have an impact on the community structure in the future. Other species that were found quite a lot included *Ficus carolis* Diels (7 individuals) and *Palaquium warbugianum* Schltr (6 individuals). This shows that there is a distribution of dominance that is not too concentrated on one species, although *Glochidion macrocarpum* Bl dominates. Several species are only represented by one individual, such as Horsfieldia sylvestis Warb, Palaquium obovatum Engl, and *Ficus benjamina* L., indicating that they may have a lower regeneration success rate or are part of a minority community in this ecosystem. Some species of the same genus, such as Ficus, have several different species represented in the community (e. g. Ficus carolis, Ficus punctata, Ficus glandulifera, Ficus benjamina, Ficus disticha, and Ficus septica). This suggests that the genus Ficus plays an important role in the community structure at the sapling level. The presence of a variety of tree species indicates that this ecosystem has good potential for ecological stability, with relatively high species diversity. Species such as Pandanus conoideus and Intsia bijuga, which have both ecological and economic value, indicate the potential for sustainable resource utilization if managed properly.

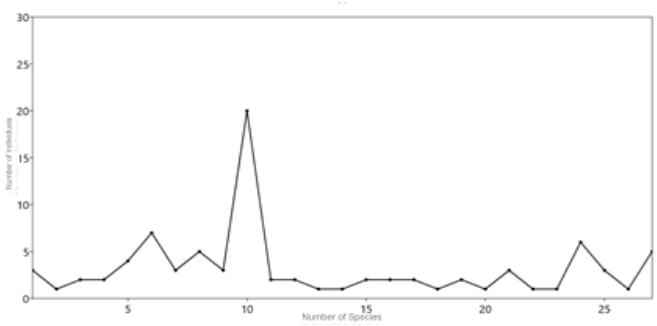
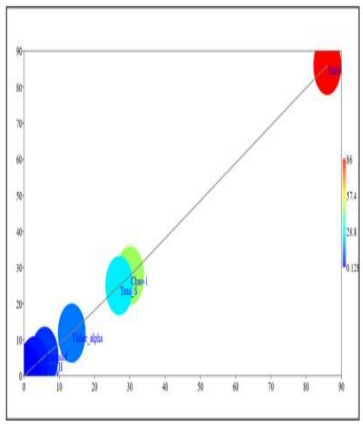


Figure 4. Number of species and individuals at sapling level

Biodiversity is one of the important indicators in understanding the health and stability of an ecosystem. Data generated from various diversity indices allow us to describe not only the number of species present, but also how these species are distributed in the ecosystem. In this case, various diversity, evenness, and dominance indices provide a deeper picture of population dynamics (Kitikidou et al., 2024; Thukral et al., 2019; Jost, 2010).



	A	Lower	Upper
Taxa_S	27	25	27
Individuals	86	86	86
Dominance_D	0.08599	0.0622	0.1284
Simpson_1-D	0.914	0.8716	0.9378
Shannon_H	2.902	2.68	3.03
Evenness_e^H/S	0.6745	0.5496	0.7677
Brillouin	2.506	2.308	2.623
Menhinick	2.911	2.696	2.911
Margalef	5.837	5.388	5.837
Equitability_J	0.8805	0.8176	0.9198
Fisher_alpha	13.53	11.84	13.53
Berger-Parker	0.2326	0.1395	0.314
Chao-1	30.11	27.75	46.5

Figure 5. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Sapling Level

Figure 4 shows that the diversity of this ecosystem is reflected in two important indices, namely Shannon (H) and Simpson (1-D). The Shannon index (3.902) indicates that the species diversity in the community is very high. The Shannon index is usually used to measure the uncertainty in predicting species that will be randomly selected from a sample. The higher the Shannon value, the greater the diversity. This value indicates that the community not only has many species but also that individuals are distributed fairly evenly among the species. Simpson's Index (1-D) of 0.91 confirms this. The Simpson index calculates the probability that two individuals randomly selected from a sample will come from different species. A value close to 1 indicates that this community has very good diversity.

This diversity is also seen in the index that measures species richness. Margalef (5.83), which is used to assess the number of species about the number of individuals in a sample. The higher the Margalef value, the greater the species richness of the community. Chao-1 (Zhao et al., 2022), which is an estimate of the total species richness, including species that may not have been observed in the sample. This suggests that the true species richness may be more than 30 species, meaning that this community may have more species than observed (Kuczynski et al., 2023; Vu Ho et al., 2023; Hartop et al., 2024). Evenness in this community is also quite good, as indicated by Evenness (0.67), which measures the distribution of individuals across species. Higher evenness values indicate a more even distribution, while lower values indicate that most individuals are in one or a few dominant species. A value of 0.67 indicates moderate evenness, meaning that most species in the community have fairly balanced

numbers of individuals. Equitability (0.88) provides further confirmation of this evenness. Equitability values approaching 1 indicate that the distribution of individuals among species is very even, and in this case, with a value of 0.88, the community can be considered to have a nearly even distribution among species.

This community also shows low species dominance, which can be measured by two indices. The Dominance Index (0.08) is a measure of how dominant a particular species is in the community. A low dominance value indicates that no species significantly dominates the community. This means that the community is more balanced in terms of species distribution. The Berger-Parker Index (0.23) supports this, which measures the proportion of individuals of the most abundant species. A lower value indicates that the most dominant species does not have a significantly greater number of individuals than other species. With a value of 0.23, this indicates that no single species significantly dominates this ecosystem. Thus, these data describe a balanced community, with high species diversity, a fairly even distribution of individuals among species, and no species dominating the population. This high diversity supports ecosystem stability because communities with more species and a more even distribution are usually better able to adapt to environmental changes (Maskell et al., 2019).

Pole-Level Vegetation Analysis

The vegetation data in Figure 5 recorded 42 individuals from 27 different species at the study site. There were 42 individual trees representing the level of vegetation regeneration at this location. There were 27 tree species recorded. This diversity indicates an ecosystem with relatively high species diversity, which can increase ecosystem stability. Glochidion macrocarpum Bl. (6 individuals) is the dominant species in this area, followed by Cholaranthus erecthus Burck. (5 individuals) and Syzygium sp. (3 individuals). The dominance of these species can affect community structure and interactions between species. However, this dominance is not excessive, because the distribution of individuals is relatively spread across several species, indicating that the diversity is still balanced. Most species are only represented by one individual (22 species). This could indicate that these species may be less successful in regeneration or only exist in small numbers at the site. For example, important species such as Pometia acuminata, Alstonia scholaris, and Medusanthera papuana were only recorded by one individual, indicating their presence as part of a minority community.

The genus Ficus has several recorded species, such as Ficus aureus, Ficus variegata, Ficus disticha, and Ficus septica, indicating the important role of Ficus in this ecosystem. Ficus usually functions as a food source for many fauna, especially birds and mammals. The presence of trees from various families (for example, Myrtaceae with Tristania microsperma and Syzygium sp., and Euphorbiaceae with *Glochidion macrocarpum*) indicates that there is regeneration from various families so that the ecosystem remains diverse and has the potential to support many forms of life. Species such as *Alstonia scholaris* and *Pometia acuminata* are trees with high ecological value in the Papua region, especially related to ecosystem functions such as providing habitat for fauna. However, the small number of individuals suggests that they may face challenges in regeneration or compete with other species. This ecosystem has a relatively high species diversity with a fairly even distribution of individuals between dominant and minority species. The dominance of species such as *Glochidion macrocarpum* and *Cholaranthus erecthus* indicates a good regeneration pattern for these species, while other species are present in smaller numbers, which needs to be monitored to ensure there is no significant population decline in the future. Further research on species interactions and regeneration patterns over time can help better understand the dynamics of this community.

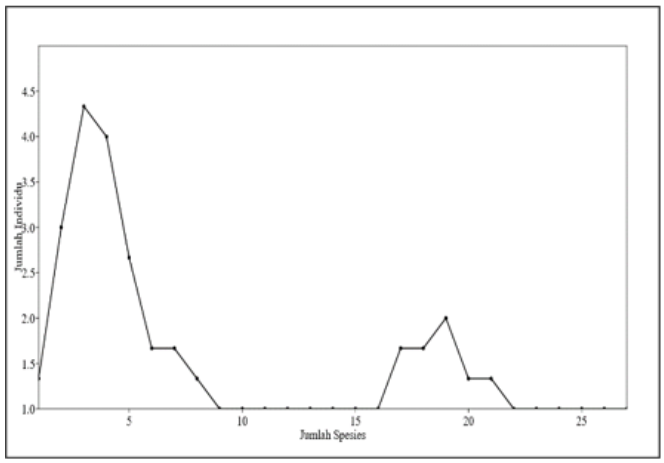


Figure 6. Number of species and individuals of pole-level vegetation

Figure 6 shows very high species diversity: Simpson, Shannon, Fisher alpha, and Margalef indices indicate that this community is very rich in species. High evenness values indicate that individuals are evenly distributed among species. Low dominance indicates that no species dominates the community. Potential species richness is greater: Chao-1 estimates indicate that there may be more species that have not been detected in the sample.

Species diversity in a community reflects the number of species present and the relative distribution of these individuals. This can be analyzed using indices

such as Simpson, Shannon, Fisher Alpha, and Margalef. The Simpson index (1-D) provides information about the probability that two individuals randomly selected from the community are from different species. A high value (close to 1) indicates high diversity. According to Roswell et al. (2021), the Simpson index is very effective in measuring dominance diversity, especially in communities with many species that are almost equal in number of individuals. The Shannon index (H') measures diversity based on the uncertainty in predicting which species will be randomly selected.

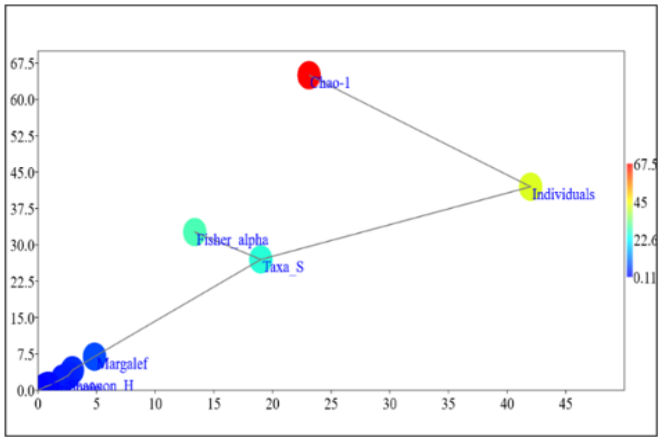


Figure 7. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Pole Level

A high Shannon value indicates a very complex community. In the literature, (Jesse et al., 2020), noted that Shannon is more sensitive to changes in species with moderate numbers, making it an important tool in the analysis of communities with diverse species. Fisher Alpha is another measure of species richness, which takes into account the distribution of rare species. Recent research from Farriols et al. (2021) shows that this index is very useful in estimating rare species in small samples. Margalef Index also takes into account species richness by considering the total number of individuals in the sample. Margalef is effective in identifying absolute species richness, especially in tropical ecosystems where less dominant species still have an important role. Evenness describes how evenly distributed individuals are among species. In this context, a high evenness value indicates that individuals are evenly distributed among species. Evenness (e^H/S) provides information about how close a species distribution is to perfect evenness. Values close to 1 indicate that the number of individuals among species does not vary much. As noted by Berry et al. (2014), high evenness generally occurs in stable communities, where no species significantly dominates. High evenness in these communities indicates that species have an equal chance of survival, which increases the community's resilience to environmental change, as noted by Yan et al. (2023) in their study of ecosystem stability.

The dominance index measures the proportion of individuals represented by the dominant species in a community. A low dominance value indicates that no species dominates the community. A low dominance index (e.g., Berger-Parker) indicates that species in this community do not significantly dominate the population. According to Goswami et al. (2017), low dominance is an indicator of a balanced community, where many species have similar numbers of individuals, increasing overall diversity. The presence of low dominance in this community shows that the resource is not dominated by a single species, thus creating opportunities for more species to grow and develop in the ecosystem.

The Chao-1 index is one of the most common ways to estimate the richness of undetected species in a sample. Chao-1 estimates the number of unobserved species based on the number of rare species in the sample. A high Chao-1 value indicates that there are likely to be more undetected species in the samples taken. Torresani et al. (2024) emphasized the importance of this index for estimating the actual species richness in highly heterogeneous habitats, where some species may be rare or difficult to identify in initial field surveys. In biodiversity studies, as described by Paller (2018) and Uhl et al. (2024), Chao-1 estimates provide insight into the potential for true species richness, especially in complex ecosystems such as tropical forests.

Tree-Level Vegetation Analysis

Figure 7 shows the various plant species found in a particular area and the number of individuals of each species observed in the survey. Overall, there were 41 species identified from 12 plant families with a total of 156 individuals. The most abundant species was *Glochidion macrocarpum* from the Euphorbiaceae family with a total of 35 individuals, indicating that this species dominates the surveyed area. Other fairly dominant species were Cholaranthus erecthus (Cholaranthaceae family) with 11 individuals, and Intsia bijuga (Fabaceae family) with 8 individuals.

Ficus benjamina (Moraceae) was also recorded with 7 individuals, making a significant contribution to the community composition. Species such as Antiaris toxicaria, Ficus glandulifera, Ficus punctata, and Ficus variegata, which collectively had more than 20 individuals. Most of the species in this image are represented by only one individual. These include species such as Adenanthera microsperma, Calophyllum inophyllum, Camnosperma brevipetiolata, and Ixora pucherima. The presence of these rare species reflects the high species diversity in the area despite the low number of individuals of each

species. With a total of 39 species and 156 individuals, these results indicate that this area has a fairly high level of species diversity. This diversity is important in supporting ecosystem balance because each species can play a role in the food chain, forest regeneration, and providing habitat for fauna.

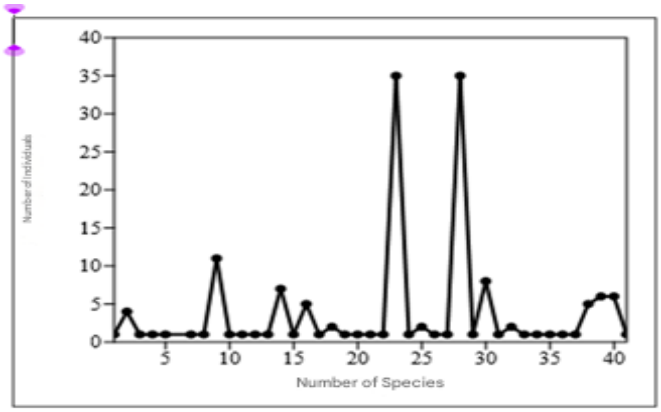


Figure 8. Number of species and individuals of tree level vegetation

Some species found have potential uses in ecology and ethnobotany. For example, *Pometia acuminata* (family Sapindaceae) and Metroxylon sago are species known as important food sources for local communities. *Canarium hirsutum* and *Cananga adorata* are also known for their traditional value as medicinal plants and sources of natural fragrances.

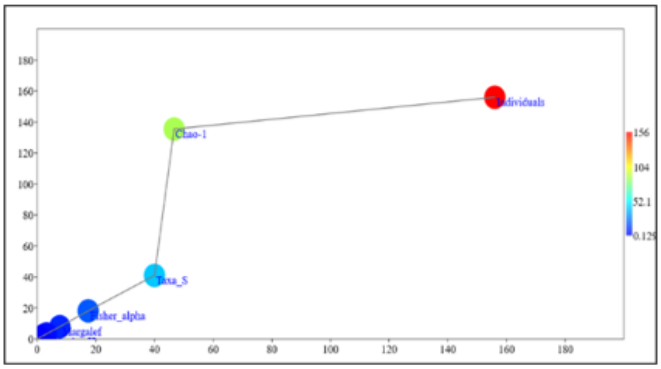


Figure 9. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Tree Level

Figure 8, shows the diversity indices such as Simpson, Shannon, Fisher alpha, and Margalef indicate that the observed community is rich in terms of the number of species. High diversity indicates that there are many species sharing the same ecosystem, which can reflect a stable and healthy ecosystem. Simpson's Index (1 - D) measures the probability that two randomly selected individuals from the community will be from different species. A high value indicates that the community is not dominated by one or a few species, but consists of a variety of species. Shannon Index (H') takes into account both the number of species (richness) and their relative abundance. Higher values reflect a more diverse community. Fisher alpha measures species diversity based on a log-normal distribution model. The higher the Fisher alpha value, the more species are in the community. Margalef Index is a measure of species richness that takes into account the number of species in a community and the sample size. This index is very useful for comparing species richness in different ecosystems. In this context, high results of these indices indicate that the analyzed community has a large number of species, which is an indicator of a healthy ecosystem with a fairly high biodiversity (Marchese, 2015; Ajijah et al., 2022).

The distribution of individuals in this data shows unevenness. A low Evenness value indicates that although there are many species, individuals are not evenly distributed among them. This indicates that there are species that are more dominant in number than others, which may be due to stronger competition or certain ecological specializations. Evenness is used to measure how evenly individuals are distributed among the species in a community. When this value is low, it means that some species dominate the community, while other species are only represented by a few individuals. Factors such as environmental conditions, resource availability, and interactions between species can affect the distribution of individuals. The dominance of certain species may reflect the presence of special adaptations or greater competitive strength than other species (Weisser et al., 2017).

The Chao-1 estimate indicates the potential presence of species that have not been detected in the sample. This means that even though the available data have identified many species, there is likely to be greater diversity in the ecosystem, especially species that are less common or difficult to observe. The Chao-1 Index estimates true species richness by accounting for rare species (e.g., species that occur only once or twice in a sample). If the Chao-1 value is higher than the number of observed species, this indicates that there are potentially additional species that have not been discovered, perhaps due to limited sample size or very rare species. The presence of high Chao-1 estimates emphasizes the importance of more extensive data collection or the use of more sensitive methods to detect hidden species, such as deeper sampling or modern genetic survey methods (eDNA) (Bell et al., 2024).

Vegetation Analysis in the Imbowiari Forest Area in 2018
Seedling Level Vegetation Analysis

Figure 9 shows that, with a total of 60 recorded plant species, the plant community in this area shows quite high diversity. Species such as Pometia pinnata (52

individuals), Syzygium sp (50 individuals), and Syzygium burupensis (46 individuals) are the most dominant. The high number of individuals in some of these species indicates their important role in the community structure. The distribution of individuals among species tends to be uneven. Species such as Pometia pinnata and Syzygium have a very high number of individuals compared to other species such as Gonocaryum sp (1 individual) and Horsfieldia sylvestris (1 individual). This unevenness may reflect habitat preferences or certain ecological adaptations that affect the distribution of species. Several species have significant dominance in this community. For example, Pometia pinnata and Syzygium sp. are very dominant in terms of number of individuals, indicating that these species may have better adaptation to local environmental conditions or have an advantage in terms of competition (Trogisch et al., 2021). Although some species have small numbers of individuals, these data indicate a diverse community and have the potential to support a rich ecosystem.

High species richness is often an indicator of a healthy ecosystem because of the diverse ecological roles played by these species. Estimates from these data also indicate the potential presence of species that have not been detected or are rarely encountered in surveys. Species with very small numbers of individuals, such as Horsfieldia sylvestris and Gonocaryum sp., could be the focus of further research to see the factors that influence their presence. Dominant species such as Pometia pinnata and Syzygium may play important roles in the structure and function of the ecosystem, such as providing food for wildlife, providing shade, or improving the soil. In addition, species such as Oncosperma tigillarium (31 individuals) also showed a significant presence and may have an equally important ecological role.

High species richness is indeed often used as an indicator of ecosystem health. This is because the diversity of species in an ecosystem reflects the variety of ecological roles that species play, such as their role in the food chain, pollination, decomposition, and nutrient cycling. When an ecosystem has a variety of interacting species, ecosystem functions such as productivity, stability, and resilience to disturbance tend to be better maintained. Research shows that species richness supports ecosystem function by maintaining stability and enabling adaptation to environmental change. This is because different species have complementary roles, which in turn strengthens the ecosystem's capacity to recover from disturbances such as climate change or human activities. Studies have also shown that this diversity contributes to the effectiveness of ecosystems in carrying out their primary functions, such as nutrient cycling and primary productivity. However, it is also important to consider that while species richness may increase in some disturbed locations, such as areas degraded by humans, this does not necessarily mean that the ecosystem is healthy overall. Species richness resulting from invasive species or habitat modification can actually reduce native ecosystem functions and homogenize global biodiversity (Li et al., 2021).

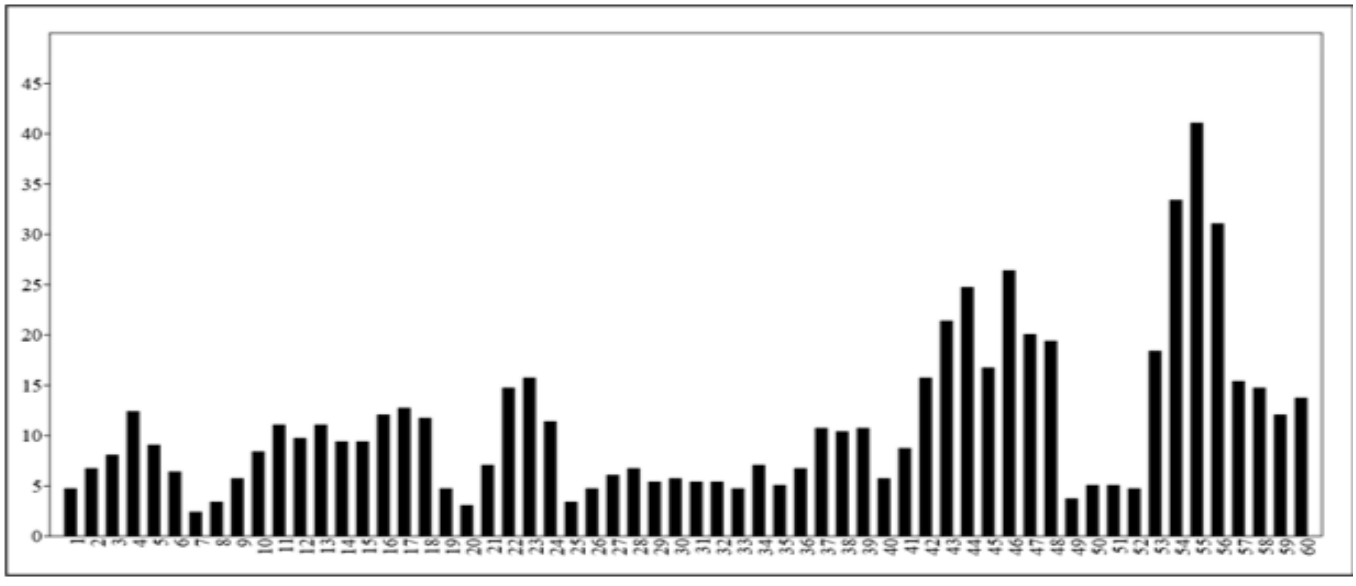


Figure 10. Number of Species and Individuals of Seedling Level Vegetation

Figure 10 shows that the dominance_D value is 0.03429, which shows that no species dominates significantly in the community. This indicates that the dominance of a species over other species is low, which is a sign of a relatively balanced ecosystem. Meanwhile, the Simpson index of 0.9657 indicates that diversity is

very high, because the closer this value is to 1, the greater the diversity of the community. This means that the proportion of species that dominate is very small, and the distribution of individuals between species is relatively even. The Shannon index of 3.681 indicates a high level of species diversity. The Shannon index (H') combines species richness and the relative distribution of individuals between species. An H' value above 3 is considered quite high, indicating a community with significant diversity. The evenness of the distribution of individuals between species (Evenness) is 0.6611, indicating that the distribution of individuals among species tends to be uneven. Some species dominate more than others, which may indicate environmental factors or competition that affect distribution (Rahman et al., 2021)

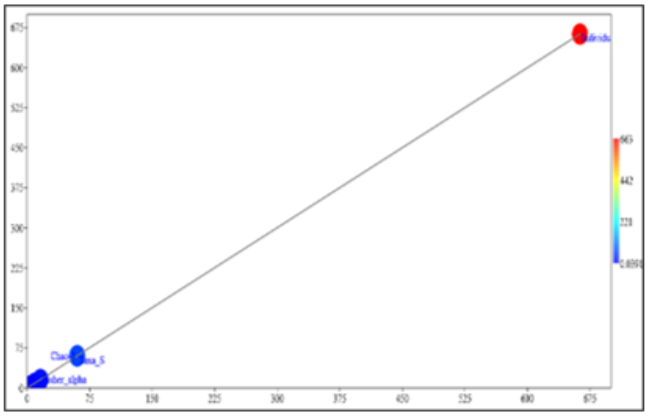


Figure 11. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Seedling Level

Another indicator of diversity is the Brillouin index value of 3.514, strengthening the results of the Shannon and Simpson indices, indicating high community diversity. The Margalef species richness index is 9.081, confirming that this community is very rich in species. This index is useful for assessing species richness based on the total number of species and the number of individuals. The higher the Margalef value, the greater the species richness in the community. Fisher alpha shows a value of 16.01, indicating high species diversity. This index is widely used to measure species diversity in communities with uneven distribution of individuals. While the estimation of potential species richness (Storch et al., 2023).

Chao-1 is 60.75, with a confidence interval between 60.13 and 70.5. This value indicates that there may be species that were not detected in this survey, indicating a potentially greater species richness in the community. Chao-1 is often used to estimate the number of species that may have been missed based on individuals that are rarely found in a sample. Species Dominance (Berger-Parker) with a value of 0.078 indicates low dominance, meaning that most species contribute significantly to the composition of the community. This value is in line with Simpson and Shannon data, indicating a relatively even distribution among species (Saeedi et al., 2022).

Sapling Level Vegetation Analysis

Figure 11 shows that there are 43 different tree species at the sapling level, spread across 20 families. This indicates a relatively high species diversity for the area. Although there are 43 tree species, the dominance of one tree species is not too striking, except for several species such as Ficus benjamina which has 20 individuals and Calopyllum inophyllum with 9 individuals. This shows that most species have a relatively even distribution of individuals, although there are some species that are more dominant in terms of the number of individuals. Most species have a small number of individuals, ranging from 1 to 3 individuals. This indicates that although the species found are diverse, most species do not dominate in number. This distribution could indicate a stable community or in the regeneration stage. Some species, such as Pometia pinnata (8 individuals) and Instia bijuga (4 individuals), may have an important role in ecosystem stability, both in terms of providing resources (such as fruit and shade) and as part of the local plant community that can provide ecological support for other flora and fauna. The data shows that the forest has a fairly good level of species diversity with light dominance by certain species such as Ficus benjamina. The distribution of the number of individuals that are spread out indicates that the tree community at the sapling level is in a relatively even condition, with several species that have the potential to dominate.

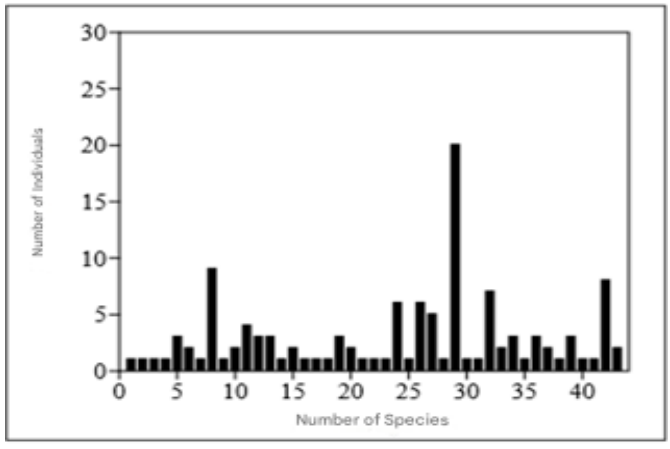


Figure 12. Number of species and individuals of sapling level vegetation

Figure 12 shows that with a Shannon_H value of 3.326, Simpson_1-D of 0.94, and Fisher_alpha of 23.83, this community is very diverse. The Shannon Index is a

measure commonly used to describe species diversity in an ecosystem. Values above 3 are generally considered to indicate high diversity, where the community has many species that contribute significantly to the total composition of individuals. Recent research has shown that high species diversity contributes to ecosystem stability and the ability to adapt to environmental changes (Zhang et al., 2023). Dominance is very low, where the Dominance_D value of 0.05594 indicates that no species significantly dominates this community. A community with a low level of dominance is often more stable and better able to withstand environmental disturbances. Research has shown that low dominance can be associated with complex and diverse species interactions, which facilitate more ecosystem functions.

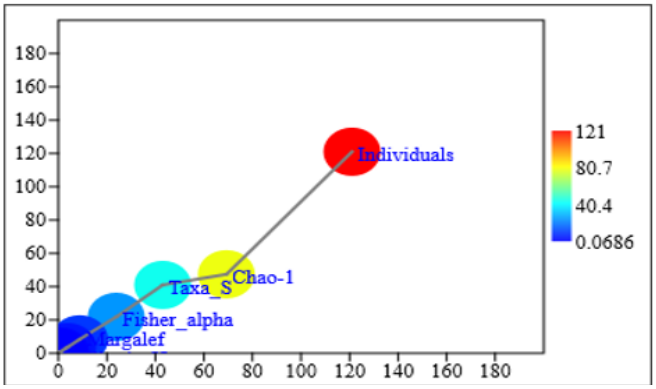


Figure 13. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Sapling Level

While the relatively even distribution in other words the fairly high Evenness value (0.64) indicates that individuals in this community are distributed fairly evenly among species. This regularity in the distribution of individuals is important because it shows that no single species dominates the population, which can indicate resilience to environmental change. Recent studies have emphasized that even distribution improves ecosystem function by ensuring a variety of biological interactions. The higher potential species richness (Chao-1 estimate) suggests that this community may have around 69 actual species, which is higher than the observed number (43 species). This suggests that further surveys are needed to reveal the full diversity within the community. Research on species richness estimates such as Chao-1 shows the importance of conducting more comprehensive surveys in diverse ecosystems to capture the full spectrum of diversity present.

Analysis of Pole-Level Vegetation

Figure 13 shows that there are 67 species of Pole-Level vegetation identified, with a total of 213 individuals observed. This indicates significant species diversity in the ecosystem, which is important for environmental health and stability. The species with the largest number of individuals is Myristica argentea with 15 individuals, followed by Syzygium sp with 16 individuals and Pometia pinnata with 10 individuals. These species may have important ecological roles in the community, such as providing food for animals, maintaining the soil, or contributing to the carbon cycle. Some species that were also detected with sufficient numbers of individuals were Intsia bijuga (7 individuals), Glochidion microcarpum (7 individuals), and Myristica sp (10 individuals). The presence of these species indicates the complexity of ecological interactions within the community and the potential to find more species that contribute to ecosystem function. Some species occur with only one individual, such as Protium sp1, Ficus septica, and Antidesma microcarpum.

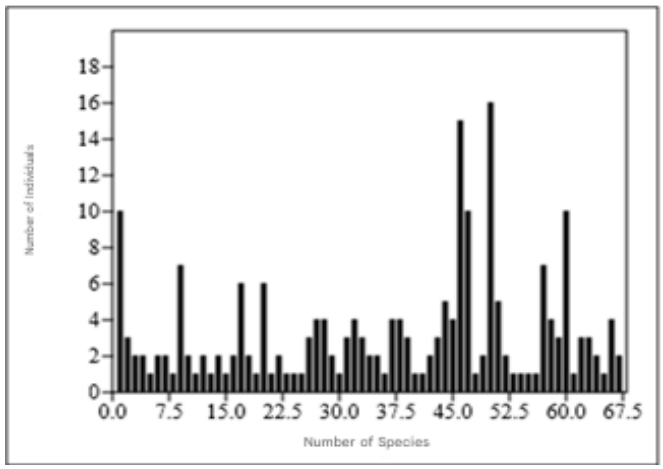


Figure 14. Number of species and individuals of pole-level vegetation

Although their numbers are low, these species may have specific roles in the ecosystem, such as pollination or seed dispersal. High species diversity as seen in these data is important for ecosystem survival. The more species in a community, the more likely they are to perform different ecosystem functions, such as pollination, seed dispersal, and nutrient processing. Species dominance dominated by a few species such as Myristica argentea and *Syzygium* sp) can be an indicator that the species have good adaptation to a particular environment. However, high dominance can also indicate risk when the environment changes, because the community may be more vulnerable if several key species are affected. Species with high numbers of individuals often have significant ecological roles. For example, Myristica argentea and Intsia bijuga often function as large trees that provide habitat and food for various wildlife species. With so many species

identified, there is the potential to discover new species, which could enrich our knowledge of the biodiversity in the area. Further surveys could help uncover more information about rare or endangered species that may be present in the habitat.

Figure 14 shows the Simpson_1-D value of 0.97, Shannon_H of 3.86, and Fisher_alpha of 33.62 indicating that this community has very high diversity. The Simpson index measures the probability that two individuals randomly selected from the community will belong to the same species. A value close to 1 indicates that the community is dominated by a few species, while a lower value indicates higher diversity. With a value of 0.97, this indicates that the species in this community support each other's diversity, indicating complex interactions between them. The Shannon index is a commonly used indicator to describe species diversity and implies how random the distribution of species is in the community. A value of 3.86 indicates that there are many species with a significant proportion of individuals. Research shows that communities with high diversity are better able to cope with environmental change and disturbance. Fisher_alpha is a good estimate to describe species richness and indicate potential diversity. A value of 33.62 indicates that this community has many species with significant contributions to the overall diversity.

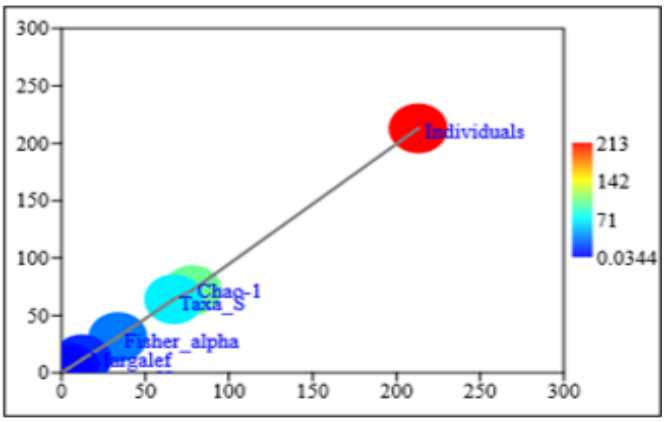


Figure 15. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Pole Level

The very low Dominance_D value (0.02) indicates that no single species dominates this community. Low dominance indicates that the community has a more even distribution of species. (This is important because low-dominance communities are often more stable and resilient to disturbance, allowing other species to persist. An Evenness value of 0.7148 and an Equitability_J of 0.92 indicate that individuals are fairly evenly distributed among species. Evenness measures the extent to which individuals are evenly distributed among species. A value above 0.7 indicates a good distribution, indicating that no one species is highly dominant, and this contributes to ecosystem stability. Equitability also assesses the distribution of individuals and indicates how fair the distribution is. A value of 0.92 indicates that each species has a nearly equal chance of contributing to the total number of individuals in this community, which is important for overall ecosystem function.

The Chao-1 estimate suggests the possibility of up to 78 species, which is greater than the observed number of 67 species. The Chao-1 estimate suggests that further surveys may be needed to identify additional species that may not have been detected. Communities that show a difference between the observed and estimated species numbers often have greater diversity, which is important for understanding the dynamics of the ecosystem as a whole. This indicates that there is potential to discover new species that have important roles in the ecosystem.

Tree Level Vegetation Analysis

Figure 15 in this data, there are 74 species identified, with a total of 211 individuals observed. This indicates a fairly high species diversity, which is important for the stability and function of the ecosystem. The species Intsia bijuga has the highest number of individuals, namely 21 individuals, followed by Prainea papuana and Pometia pinnata, with 14 and 11 individuals respectively. The presence of these dominant species can indicate the ability of these species to adapt well to the environment, as well as their potential to provide resources such as food and shelter for other species. There are several species that were only detected with one individual, such as Medusanthera laxiflorius, Chionanthus macrocarpa, and Ficus benjamina. Despite their small numbers, these species may play specific roles in the ecosystem, such as seed dispersal or as pollinators.

Species with higher numbers of individuals included Aglaia sapindina (11 individuals), Ficus septica (8 individuals), and Protium sp (8 individuals). The presence of these species can increase functional diversity in the ecosystem, supporting various ecological processes such as pollination, seed dispersal, and nutrient cycling. High species diversity is essential for ecosystem function. The more species present, the more likely they are to perform different ecological roles, which can increase the stability and resilience of the ecosystem to environmental change. With the dominance of species such as Intsia bijuga, it is important to understand the role of these species in the ecosystem. Dominant species can be indicators of ecosystem health, but they can also be signs of risk if environmental changes, such as deforestation or climate change, threaten the survival of these species. The

presence of many species with low numbers of individuals indicates the complexity of interactions in the ecosystem. These species can have symbiotic relationships or competitive interactions, which affect community structure and energy flow in the ecosystem. These data also show the potential for discovering new or rare species, especially given the high species diversity. Further surveys could aid in the identification of unknown species and deepen their contribution to local biodiversity.

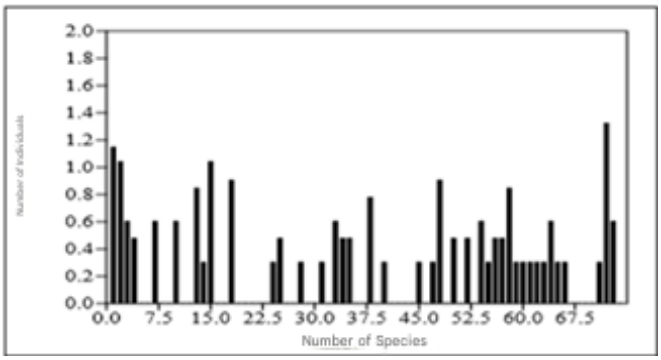


Figure 16. Number of species and individuals of tree level vegetation

Figure 16, is the value of diversity indices such as Simpson (1-D), Shannon (H), and Fisher_alpha indicating a very good level of diversity in this community. Simpson (1-D) with a value of 0.968 indicates that there is a low probability for two individuals taken randomly from this community to belong to the same species. This indicates a very high species diversity, where many species have a balanced number of individuals. Shannon (H) which reaches 3.87 indicates a good level of diversity. This value reflects the diversity of species types which are not only based on the number of species but also on the proportion of individuals among different species. The higher the H value, the more variation there is in the composition of the community. Fisher_alpha of 40.54 is another indicator of high diversity, where this value reflects the potential richness of species in the community. Fisher_alpha is often used to estimate species richness in ecosystems.

A very low Dominance_D value (0.03196) indicates that no species dominates this community. Low dominance is essential for maintaining ecosystem stability. When no single species dominates, this often indicates that the community is more resilient to environmental changes and is better able to adapt to a variety of conditions. The Evenness (0.64) and Equitability_J (0.89) values indicate that the distribution of individuals among species is fairly even. Higher evenness indicates that not only are there many species, but also that the number of individuals of each species is not much different from each other. This creates a more balanced community, where one or two species do not dominate. Equitability_J, which is close to 1, indicates that the proportion of individuals between species is similar. This even distribution is important because it can increase ecosystem stability and encourage better ecosystem function. In the Indonesian Journal of Conservation highlights the importance of biodiversity in maintaining ecosystem balance and explains how even distribution between species can affect ecosystem stability.

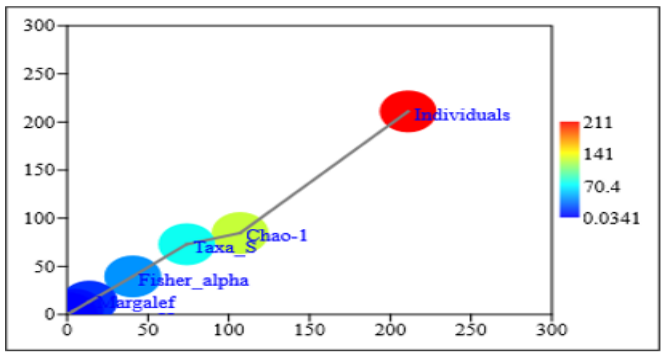


Figure 17. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Tree Level

This study includes various indicators of diversity, including Equitability_J, and how the value approaches 1. He notes that diverse ecosystems are more resistant to change and that the loss of one species can disrupt the balance, emphasizing the importance of even distribution in maintaining ecosystem function. Potential for greater species richness Where the Chao-1 estimate shows that there may be up to 107 species in this community, exceeding the number of observed species (74 species). This indicates the potential to find more species if further surveys are conducted. The discovery of new species not only enriches biodiversity but can also provide new insights into ecological interactions and ecosystem function (36). It is important to continue further research in this community, because the wealth of unidentified species could have significant ecological and conservation value.

Vegetation Analysis in Imbowiari Forest Area in 2024
Seedling Level Vegetation Analysis

The total species in the table include 72 species with a total of 614 individuals. This shows a fairly high diversity in the community of species studied. Pometia pinnata (52 individuals) and Syzygium sp (59 individuals) are the species with the highest number of individuals. The presence of these species shows the potential for dominance in the local ecosystem and can affect community structure. Oncosperma tigillarium (31

individuals) and Osmoxylon novoguinensis (23 individuals) also show significant numbers, indicating their important role in the ecosystem. Several species, such as Endopspermum moluccanum and Ficus annulata Bl (1 individual each), show very low populations. This could indicate that the species may be at risk or not in favorable conditions can be shown in Figure 17.

These data also show ecosystem equilibrium, where it can be seen that dominance is low. With the number of individuals distributed among various species, no species dominates significantly. This could mean that this community is relatively stable and more resistant to environmental disturbances. This low dominance could indicate good genetic diversity and adaptability to environmental changes. In addition, this also shows ecosystem resilience, where when no single species dominates, this community is more likely to have a better adaptive capacity. This allows them to cope with changing environmental conditions, such as climate change or pressure from human activities.

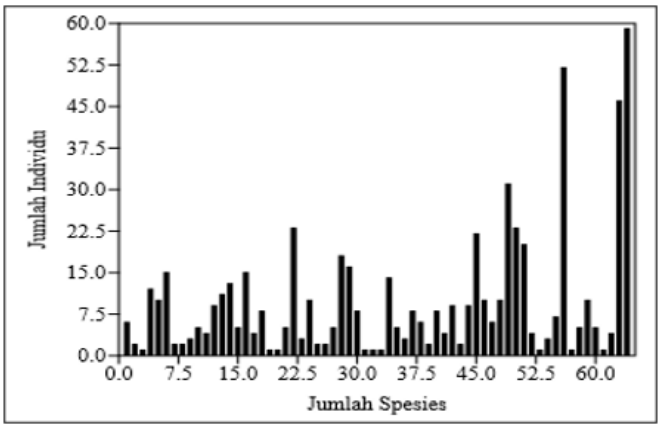


Figure 18. Graph of Number of Species and Individuals of Seedling Vegetation

The Simpson_1-D value (0.968), Shannon_H (3.65), and Fisher_alpha (40.54) indicate that this community has high diversity and can be seen in Figure 18. The high Simpson_1-D value indicates that the probability of two individuals randomly selected from the community comes from different species is very high. In addition, Shannon_H provides information about species richness and evenness of species distribution in the community. This high value confirms that many species are present with a relatively balanced number of individuals, thus indicating a diverse community. Fisher_alpha, which measures the number of species in relation to the number of individuals, also shows a high value, supporting the conclusion about diversity.

The Dominance_D value (0.03196) shows very low dominance. This means that no one species dominates the community. This low dominance strengthens the conclusion that the high diversity in the community is not dominated by one species, but instead, the distribution of species is quite even (4)(7). The Evenness value (0.64) and Equitability_J (0.89) provide an overview of the distribution of individuals among species. Evenness measures the equality of the distribution of individuals among species, and although this value does not reach 1 (which is a completely even distribution), it still shows that the distribution of individuals is relatively balanced across species. Equitability_J, which measures the relative distribution of species richness, shows that almost all species have an even representation in the community, although there may be a slight imbalance.

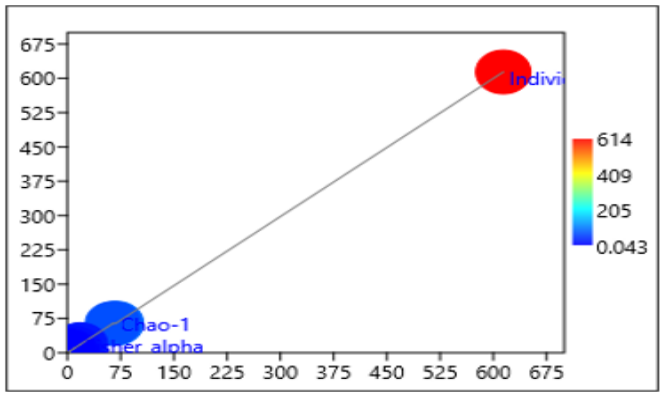


Figure 19. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Seedling Level

Potential for Greater Species Richness: Chao-1 provides an estimate of the number of potential unobserved species in the community. The Chao-1 estimate of 107 indicates that there are likely more species in the community than the number of species observed (74 species). This suggests that with increased sampling effort, additional species that have not been identified to date may be discovered. The difference between the number of species observed and estimated suggests a greater potential for species richness in this community (Aggemyr et al., 2018).

Sapling Level Vegetation Analysis

Based on Figure 19, the vegetation data at the sapling level shows that there are 64 plant species and 631 individuals. Pometia pinnata with 52 individuals and Syzygium burupensis with 46 individuals show dominance in this vegetation community. These two species likely play an important role in the local ecosystem, either in providing shelter, food, or as species that regulate forest composition. Other species with significant numbers of individuals such as Oncosperma tigillarium (31 individuals), Osmoxylon novoguinensis (23 individuals), and Ficus pubinervis (23 individuals)

also contributed to the structural and functional diversity at the sapling level. There were a total of 72 species at the sapling level with varying numbers of individuals. This shows a fairly high level of diversity, which is an indicator that this ecosystem is functioning well and supports various plant species with different ecological roles.

Species with small numbers of individuals, such as Endopspermum moluccanum, Ficus annulata, Palaquium obovatum, and Scindapsus aureus (1 individual each), indicate that these species may have a more vulnerable status or face environmental conditions that are less supportive of their growth. Some species such as Elaeocarpus sphaericus (19 individuals) and Glochidion macrocarpum (20 individuals) may play a role in seed dispersal and pollination. In addition, the presence of species from various families such as Ficus, Syzygium, and Palaquium reflects the various ecosystem services provided by this forest.

Although some species dominate, the presence of many species with relatively small numbers of individuals indicates a balance in this vegetation community, where interactions between large and small species can create diverse ecological dynamics. This interpretation suggests that this ecosystem is quite balanced with some species dominating and others having more specialized roles. The role of each species in the local food web and ecological cycles also needs to be taken into account for a more comprehensive understanding.

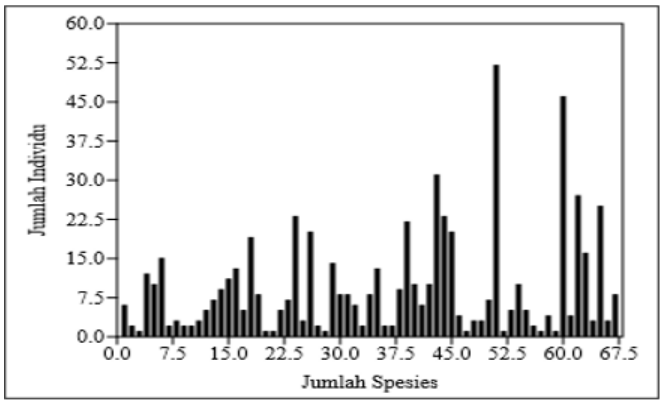


Figure 20. Graph of the Number of Species and Individuals of Vegetation at the Sapling Level

Figure 20 shows that the dominance value is (0.03). A low dominance value indicates that no one species dominates the community excessively. In a more balanced ecosystem, species tend to have a more equal opportunity to compete and thrive. Low dominance is associated with high species diversity, indicating ecological balance. The Simpson_1-D value shows the number (0.9684). This value is close to 1, indicating high diversity. This value indicates that the possibility of two randomly selected individuals coming from different species is very large, describing a community with a high level of diversity.

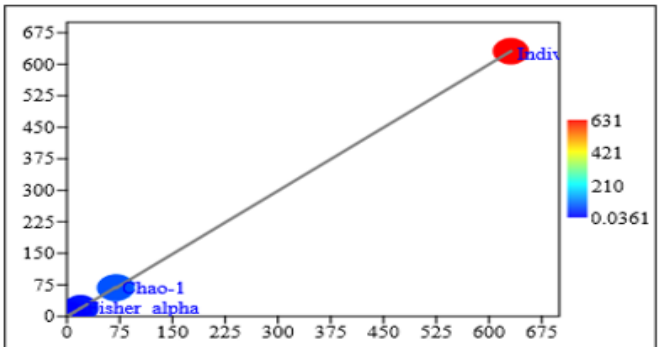


Figure 21. Number of Species, Dominance Ind, Simpson Ind, H', Evenness, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Sapling Level

The high Shannon Index H (3.773) indicates excellent species diversity in this community. Shannon measures both species richness (number of species) and balance (number of individuals per species). The evenness e^H/S (0.64) is here 0.64, indicating that the distribution of individuals among species is fairly balanced, although not perfect. This moderate evenness indicates that some species may be more dominant than others, but not significantly so. The Brillouin Index is useful in data with a strict definition, providing a more accurate picture of diversity in a fully known community. A value of 3.585 indicates high diversity. The Menhinick Index shows a value of (2.707). This index measures the ratio of the number of species to individuals and provides an idea of the composition of the community. High values indicate a relatively balanced community. Inkes Margalef shows a value (10.39 used to estimate species richness in a community. A value of 10.39 reflects an ecosystem with significant species richness, indicating the number of species present.

The balance of individual distribution between species is close to 1, such as 0.89, indicating an almost even distribution between species, indicating a balanced community. The evenness index shows an alpha value (19.35) which is an indicator used to measure species diversity. High values indicate the potential for great diversity in the community. While species dominance shows a number (0.08). This index measures the dominance of the most abundant species. Low values indicate that no single species dominates the ecosystem, providing a positive indication of community balance. Chao-1 estimates estimate the number of species that may not have been identified. With a value of 70.80, this indicates that there are likely other species that have not been detected in this survey (Wohlgemuth et al., 2016).

Pole Level Vegetation Analysis

Figure 21 shows that there are 76 tree species at the pole level with a total of 1.01 individuals. The species with the most individuals are Alstonia scholaris (55 individuals), Ficus aureus (51 individuals), and Celtis phylipinensis (50 individuals). This shows the relative dominance of several species in the pole community. Species such as Allophylys cobe, Camnosperma brevipetiolata, Cholaranthus erecthus, Glochidion macrocarpum, Mastixiodendron pachyclados, and Virbunum corieceum are also quite numerous with around 40-50 individuals. This shows that the pole community has a good level of diversity, with a fairly even distribution among different species. Most species are only represented by one or a few individuals, such as Pometia pinnata, Cinnamomum culilawang, Litsea glutinosa, and Metroxyln sago. This suggests that there are many minor species that may be less common or present in smaller numbers in the pole regeneration phase. The presence of diverse species, ranging from species with low numbers of individuals to dominant ones, may reflect the health of the ecosystem. This diversity suggests the possibility of a relatively stable community with good ecological succession potential. Some species such as Myristica sulcata (33 individuals) and Prainea papuana (37 individuals) may have important roles in this ecosystem, either as providers of food sources or habitat for certain fauna. With a total number of 1.01 individuals, the composition of this community is large enough to indicate that the community at the pole level is developing and heading towards a mature phase, with good species regeneration.

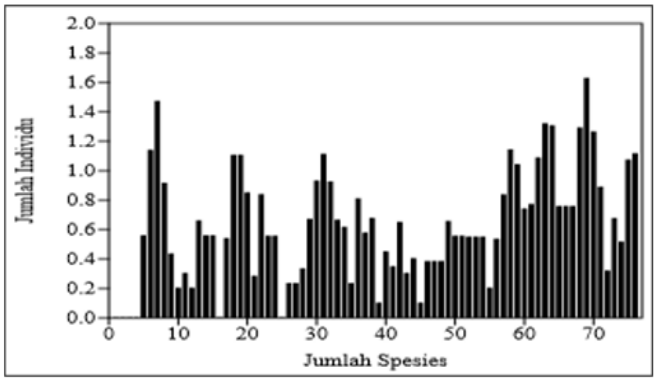


Figure 22. Graph of the number of species and individuals of pole-level vegetation

The dominance value is in the low category, namely 0.03. This low dominance value indicates that no species dominates significantly in the community. The index of 3.4, which is in the high category, indicates an even distribution of individuals among the various species in the community. While its uniformity with a value of 0.43, which means a moderate level of uniformity, indicates that although there are many species, the distribution of individuals is not completely even. The accuracy of species diversity is also indicated by the Brillouin index (3.37). The Brillouin index measures species diversity by taking into account sample size, the results show a diverse community. To achieve a value of 0.80. A relatively high level of uniformity, indicating a fairly even distribution among species (Triyadi & Toni, 2023) which can be seen in Figure 22.

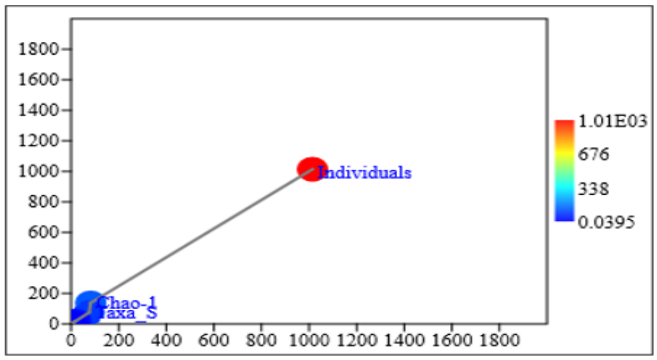


Figure 23. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Sapling Level

Tree Level Vegetation Analysis

Figure 23 shows that there are 96 different species with a total of 719 individuals. This high diversity indicates a complex and healthy ecosystem, with many different species contributing to the stability of the ecosystem. The species Ficus benjamina L. with 50 individuals and Glochidion macrocarpum Bl. with 37 individuals are the two species that dominate this community. However, the previous low overall dominance value (0.03) indicates that although there are species with a larger number of individuals, the distribution is still relatively balanced among the other species. There are several species that only have one individual, such as Adenanthera microsperma, Aglaia culculata, and Antidesma microcarpum. The presence of species with very few individuals may indicate that the species is rare or not dominant in this ecosystem.

There are other species that have a more balanced number of individuals, such as Myristica argentea and Myristica subalulata which each have 8 individuals, or Syzygium sp and Pisonia sp which have 12 individuals. This indicates that these species, although not dominant, have an important role in the ecosystem. Many of the species listed are important trees in tropical forests, such as Intsia bijuga (ironwood) and Canarium hirsutum which play an important role in providing resources such as wood and food for wildlife. Their presence indicates that this habitat supports key species in the ecosystem.

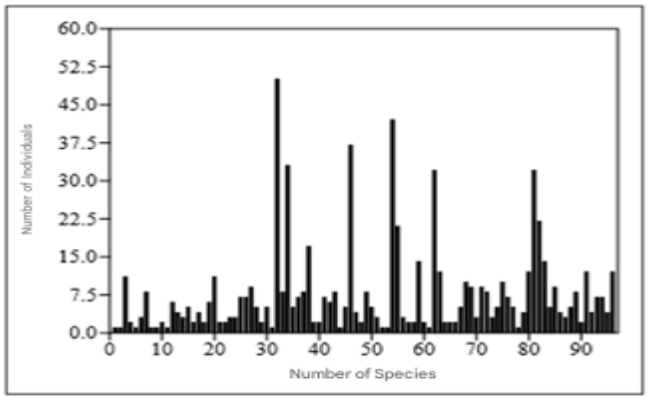


Figure 24. Graph of the number of species and individuals of tree-level vegetation

The Simpson_1-D index (0.9745) shows a value close to 1 which indicates high diversity, meaning that this community has an even distribution of individuals among species. Shannon_H (4.076) is a value to measure species diversity, and a value of 4 indicates very high diversity. The Fisher_alpha index (29.77) indicates that this community has very high diversity. The greater the Fisher alpha value, the higher the level of species diversity (Romero et al., 2022).

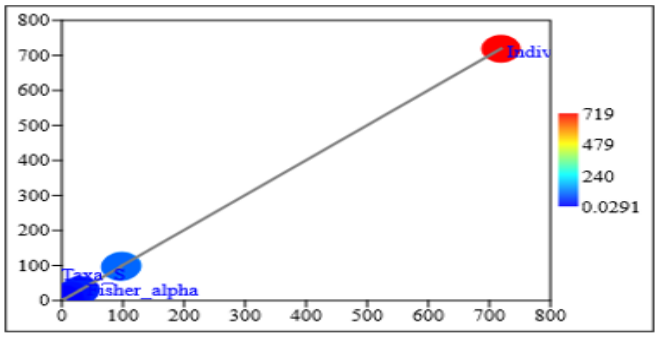


Figure 25. Number of Species, Dominance Ind, Simpson Ind, H', Evennes, Brillouin, Menhinick, Margalef, Equitability, Fisher_alpha, Berger-Parker, Chao-1 at Tree Level

While evenness is at the value (0.61). This is a measure of evenness, with a relatively moderate value, meaning that the distribution of individuals among species is not completely even but quite good. Distribution of species with a value (0.89). This value indicates that the distribution of species is quite even, with few species dominating.

Comparative Data on the Number of Species, Individuals and Diversity for All Levels in 2014, 2018 and 2024

Number of Species

At the seedling level, the number of species increased significantly from 21 (2014) to 60 (2018), and continued to increase to 72 (2024). This shows an increase in regeneration diversity at the seedling level, which is an indication of better regeneration in the understory. At the sapling level, there was an increase in the number of species from 27 (2014) to 43 (2018) and 64 (2024). This indicates that growth and regeneration at the middle (sapling) stage also increased over time. The pole level saw a dramatic increase in the number of species, from 26 (2014) to 67 (2018) and 76 (2024). This indicates the development of regeneration in larger trees. At the tree level, the number of species increased steadily from 41 (2014) to 74 (2018) and 96 (2024). This indicates success in reaching the mature tree stage, which is important for long-term ecosystem stability.

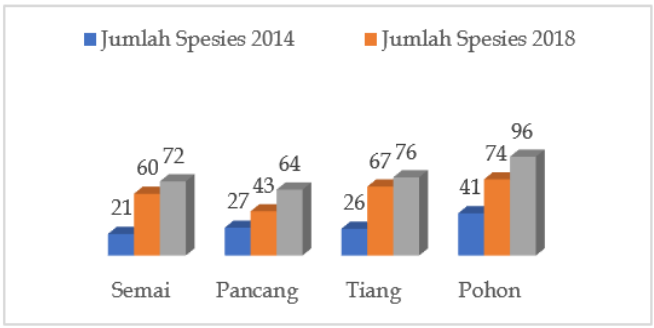


Figure 26. Number of species in 2014, 2018 and 2024

Number of Individuals

At the seedling level, the number of individuals increased significantly from 68 (2014) to 663 (2018), although it decreased slightly to 614 (2024). The decrease from 2018 to 2024 may be due to environmental factors or disturbances affecting seedling regeneration. At the sapling level, the number of individuals increased from 86 (2014) to 121 (2018), and jumped sharply to 631 (2024). The large increase in 2024 could be due to more favorable conditions for the growth of young plants. The number of individuals at the pole level increased from 42 (2014) to 213 (2018) and reached 1,014 (2024). This very large increase indicates good development in vegetation growth towards mature trees. Meanwhile, at the tree level, the number of individuals increased from 156 (2014) to 211 (2018), and then to 719 (2024). This reflects a maturing ecosystem with many trees having reached the adult stage.

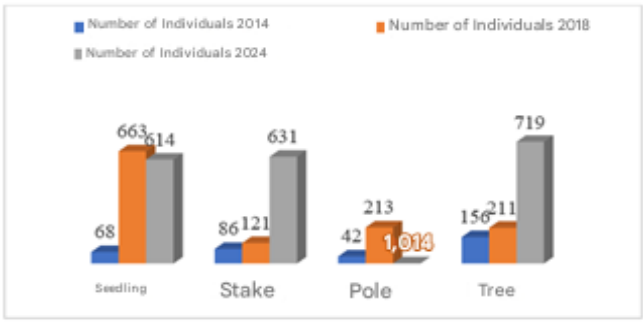


Figure 27. Number of individual trees in 2014, 2028 and 2024

Diversity Index (Shannon-Wiener)

At the seedling level, the diversity index increased from 2.77 (2014) to 3.68 (2018), with a slight decrease to 3.65 (2024). This suggests that despite the increase in the number of species, the distribution of individuals may have become slightly less even in 2024. At Saplings, it increased from 2.90 (2014) to 3.32 (2018) and 3.77 (2024), indicating an increase in diversity and a more even distribution in the sapling community over time. At the pole level, the diversity index showed an increase from 3.08 (2014) to 3.86 (2018), but a slight decrease to 3.49 (2024). This decrease may indicate that the dominance of some species becomes stronger in 2024. At the tree level, the diversity index increased steadily from 2.78 (2014) to 3.87 (2018), and 4.07 (2024). This indicates a significant increase in diversity and balance of individual distribution among tree species.

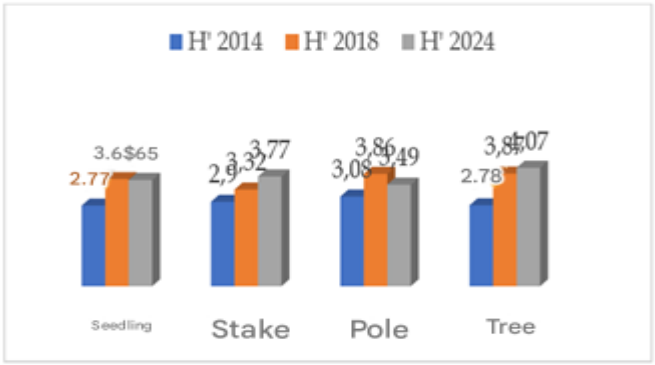


Figure 28. Vegetation diversity in 2014, 2018 and 2024

Overall, the number of species and diversity indices increased at all levels from 2014 to 2024. This indicates successful forest regeneration and increased ecosystem complexity. The increased diversity also reflects increased ecosystem stability and capacity to support more species. The number of individuals at all levels showed a significant increasing trend, especially in saplings, poles and trees in 2024. This indicates environmental conditions that support faster growth and regeneration. The increase in diversity indices at all levels (especially trees) indicates that the vegetation community is increasingly balanced, where no species dominates too much, creating a more even distribution and allowing more diverse species to thrive. Although there was a decrease in the number of seedling individuals in 2024 compared to 2018, diversity remained high. This decrease could be a sign of greater competition or environmental pressures that reduce the success of regeneration at the seedling level.

Vegetation Relationship in the Time Period of 2014, 2018 and 2024 in the Development of Birdwatching in Barawai Village

In the context of birdwatching development, especially related to Paradisaea minor jobiensis in Barawai Village, Raimbawi, analysis of vegetation at various levels—seedlings, saplings, poles, and trees—in 2014, 2018, and 2024 is very important. The following is an explanation of the relationship between the vegetation and the birdwatching development plan:

Seedling Level

This level refers to the initial growth of vegetation and provides an overview of the potential for forest regeneration. The existence of good seedlings will ensure the sustainability of vegetation in the future, which will create a suitable habitat for birds of paradise such as Paradisaea minor jobiensis. In 2014, 2018, and 2024, seedling data can indicate whether there is an increase or decrease in forest regeneration, which directly affects the availability of nesting sites and food sources for these birds.

Sapling Level

Vegetation at the sapling level indicates more mature vegetation, but has not yet reached the size of a mature tree. At this level, vegetation serves as a hiding place and starting point for young birds. Data from 2014, 2018, and 2024 can provide insight into habitat quality in the growth stage, which is a direct indicator of the sustainability of the Paradisaea minor jobiensis population in the area.

Pole Level

At this level, trees begin to become more stable and mature. Vegetation at the pole level provides structural support for the surrounding environment and contributes to ecosystem diversity. These trees are important for the nesting behavior of birds of paradise. If analysis during this period shows an increase in pole vegetation, this can increase the opportunity for birdwatching development because birds of paradise will be more frequently seen in habitat that supports their nesting needs.

Tree Level

Tree level vegetation, as a mature forest structure, is the main habitat for birds of paradise. In 2024, for example, an increase in the number and distribution of trees indicates a stable habitat for birdwatching. Mature trees provide an ideal place for the Cenderawasih to perform its dancing act, which is the main attraction of birdwatching. Tree data from 2014 to 2024 can reveal habitat dynamics and help determine the best locations for birdwatching activities in the area. Vegetation changes at all levels during the 2014 to 2024 time period provide a clear picture of the condition of the Paradisaea minor jobiensis habitat. This data will be an important basis for birdwatching planning because each level of vegetation contributes to habitat quality, from seedlings

to mature trees. Effective bird watching depends on the availability of habitat that is suitable for the Cenderawasih life cycle, so the results of this vegetation analysis will determine the focal points for birdwatching development in Barawai Village, Raimbawi District.

Conclusion

The results obtained from the analysis of vegetation in the Imbiwiari Barawai forest area in 2014, 2018 and 2024 showed varying data at all levels. When viewed from the number of species at the seedling level, the number of species increased significantly from 21 (2014) to 60 (2018), and continued to increase to 72 (2024). At the sapling level, there was an increase in the number of species from 27 (2014) to 43 (2018) and 64 (2024). The pole level experienced a dramatic increase in the number of species, from 26 (2014) to 67 (2018) and 76 (2024). At the tree level, the number of species experienced a steady increase from 41 (2014) to 74 (2018) and 96 (2024). At the number of individuals at the seedling level, there was a significant increase from 68 (2014) to 663 (2018), although it decreased slightly to 614 (2024). Decrease from 2018 to 2024. Sapling level, there was an increase in the number of individuals from 86 (2014) to 121 (2018), and jumped sharply to 631 (2024). The number of individuals at the pole level increased from 42 (2014) to 213 (2018) and reached 1,014 (2024). While at the tree level, the number of individuals increased from 156 (2014) to 211 (2018), and then to 719 (2024). In vegetation diversity, it shows that for the seedling level, the diversity index increased from 2.77 (2014) to 3.68 (2018), with a slight decrease to 3.65 (2024). At Saplings, it increased from 2.90 (2014) to 3.32 (2018) and 3.77 (2024). At the pole level, the diversity index showed an increase from 3.08 (2014) to 3.86 (2018), but slightly decreased to 3.49 (2024). At the tree level, the diversity index increased steadily from 2.78 (2014) to 3.87 (2018), and 4.07 (2024).

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Author Contributions

E. K. R, in charge of collecting data in the field and preparing and compiling the final research report and publication manuscript. B. T. R, in charge of interpreting vegetation data and also discussing the article manuscript. A. H. R, is in charge of discussing the research results in this manuscript. D. R. J, is in charge of analyzing data using PAST software. R. A, in charge of creating a research map based on coordinate data obtained in the field.

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Conflicts of Interest

The implementation of this research was carried out as well as possible without any problems within the research team but also all parties involved especially the Dorey Jaya group.

References

Aggemyr, E., Auffret, A. G., Jädergård, L., & Cousins, S. A. O. (2018). Species richness and composition differ in response to landscape and biogeography. *Landscape Ecology*, *33*(12), 2273–2284. https://doi.org/10.1007/s10980-018-0742-9

Ajijah, L. N., Safe'i, R., Yuwono, S. B., & Kaskoyo, H. (2022). Forest Health Analysis Based on Flora Biodiversity Indicators in Gapoktan Harapan Sentosa KPHL BatuTegi, Lampung. *IOP Conference Series: Earth and Environmental Science*, *995*(1), 012003. https://doi.org/10.1088/1755-1315/995/1/012003

Bell, K. L., Campos, M., Hoffmann, B. D., Encinas-Viso, F., Hunter, G. C., & Webber, B. L. (2024). Environmental DNA methods for biosecurity and invasion biology in terrestrial ecosystems: Progress, pitfalls, and prospects. *Science of The Total Environment*, *926*, 171810. https://doi.org/10.1016/j.scitotenv.2024.171810

Berry, D., & Widder, S. (2014). Deciphering microbial interactions and detecting keystone species with co-occurrence networks. *Frontiers in Microbiology*, *5*. https://doi.org/10.3389/fmicb.2014.00219

Brockerhoff, E. G., Barbaro, L., Castagneyrol, B., Forrester, D. I., Gardiner, B., González-Olabarria, J. R., Lyver, P. O., Meurisse, N., Oxbrough, A., Taki, H., Thompson, I. D., Van Der Plas, F., & Jactel, H. (2017). Forest biodiversity, ecosystem functioning

and the provision of ecosystem services. *Biodiversity and Conservation*, *26*(13), 3005–3035. https://doi.org/10.1007/s10531-017-1453-2

Cooper, N., Brady, E., Steen, H., & Bryce, R. (2016). Aesthetic and spiritual values of ecosystems: Recognising the ontological and axiological plurality of cultural ecosystem 'services.' *Ecosystem Services*, *21*, 218–229. https://doi.org/10.1016/j.ecoser.2016.07.014

Correia, A. M., & Lopes, L. F. (2023). Revisiting Biodiversity and Ecosystem Functioning through the Lens of Complex Adaptive Systems. *Diversity*, *15*(8), 895. https://doi.org/10.3390/d15080895

De Zoysa, M. (2022). Ecotourism Development and Biodiversity Conservation in Sri Lanka: Objectives, Conflicts and Resolutions. *Open Journal of Ecology*, *12*(10), 638–666. https://doi.org/10.4236/oje.2022.1210037

Farriols, M. T., Ordines, F., & Massutí, E. (2021). N90, a Diversity Index Sensitive to Variations in Beta Diversity Components. *Diversity*, *13*(10), 489. https://doi.org/10.3390/d13100489

Goswami, M., Bhattacharyya, P., Mukherjee, I., & Tribedi, P. (2017). Functional Diversity: An Important Measure of Ecosystem Functioning. *Advances in Microbiology*, *07*(01), 82–93. https://doi.org/10.4236/aim.2017.71007

Hartop, E., Lee, L., Srivathsan, A., Jones, M., Peña-Aguilera, P., Ovaskainen, O., Roslin, T., & Meier, R. (2024). Resolving biology's dark matter: Species richness, spatiotemporal distribution, and community composition of a dark taxon. *BMC Biology*, *22*(1), 215. https://doi.org/10.1186/s12915-024-02010-z

Jesse, W. A. M., Molleman, J., Franken, O., Lammers, M., Berg, M. P., Behm, J. E., Helmus, M. R., & Ellers, J. (2020). Disentangling the effects of plant species invasion and urban development on arthropod community composition. *Global Change Biology*, *26*(6), 3294–3306. https://doi.org/10.1111/gcb.15091

Jia, X., Tao, D., Ke, Y., Li, W., Yang, T., Yang, Y., He, N., Smith, M. D., & Yu, Q. (2022). Dominant species control effects of nitrogen addition on ecosystem stability. *Science of The Total Environment*, *838*, 156060. https://doi.org/10.1016/j.scitotenv.2022.156060

Jost, L. (2010). The Relation between Evenness and Diversity. *Diversity*, *2*(2), 207–232. https://doi.org/10.3390/d2020207

Khosravi Mashizi, A., & Sharafatmandrad, M. (2024). Linking ecosystems to public health based on combination of social and ecological systems. *Scientific Reports*, *14*(1), 9911. https://doi.org/10.1038/s41598-024-60814-z

Kitikidou, K., Milios, E., Stampoulidis, A., Pipinis, E., & Radoglou, K. (2024). Using Biodiversity Indices Effectively: Considerations for Forest Management. *Ecologies*, *5*(1), 42–51. https://doi.org/10.3390/ecologies5010003

Kuczynski, L., Ontiveros, V. J., & Hillebrand, H. (2023). Biodiversity time series are biased towards increasing species richness in changing environments. *Nature Ecology & Evolution*, *7*(7), 994–1001. https://doi.org/10.1038/s41559-023-02078-w

Li, S., Liu, W., Lang, X., Huang, X., & Su, J. (2021). Species richness, not abundance, drives ecosystem multifunctionality in a subtropical coniferous forest. *Ecological Indicators*, *120*, 106911. https://doi.org/10.1016/j.ecolind.2020.106911

Listmann, L., Hattich, G. S. I., Matthiessen, B., & Reusch, T. B. H. (2020). Eco-Evolutionary Interaction in Competing Phytoplankton: Nutrient Driven Genotype Sorting Likely Explains Dominance Shift and Species Responses to CO2. *Frontiers in Marine Science*, *7*, 634. https://doi.org/10.3389/fmars.2020.00634

Marchese, C. (2015). Biodiversity hotspots: A shortcut for a more complicated concept. *Global Ecology and Conservation*, *3*, 297–309. https://doi.org/10.1016/j.gecco.2014.12.008

Maskell, L. C., Botham, M., Henrys, P., Jarvis, S., Maxwell, D., Robinson, D. A., Rowland, C. S., Siriwardena, G., Smart, S., Skates, J., Tebbs, E. J., Tordoff, G. M., & Emmett, B. A. (2019). Exploring relationships between land use intensity, habitat heterogeneity and biodiversity to identify and monitor areas of High Nature Value farming. *Biological Conservation*, *231*, 30–38. https://doi.org/10.1016/j.biocon.2018.12.033

Meng, L., Li, Y., Chen, L., Sui, M., Zhang, G., Liu, Q., Chen, D., Wu, Y., Yang, Z., Chen, S., Yang, R., & Zang, L. (2024). Variations in species diversity patterns and community assembly rules among vegetation types in the karst landscape. *Frontiers in Plant Science*, *15*, 1338596. https://doi.org/10.3389/fpls.2024.1338596

Müllner, A., Eduard Linsenmair, K., & Wikelski, M. (2004). Exposure to ecotourism reduces survival and affects stress response in hoatzin chicks (Opisthocomus hoazin). *Biological Conservation*, *118*(4), 549–558. https://doi.org/10.1016/j.biocon.2003.10.003

Paller, M. H. (2018). Estimating Fish Species Richness across Multiple Watersheds. *Diversity*, *10*(2), 42. https://doi.org/10.3390/d10020042

Rahman, A. U., Khan, S. M., Ahmad, Z., Alamri, S., Hashem, M., Ilyas, M., Aksoy, A., Dülgeroğlu, C., & Shahab Ali, G. K. (2021). -Impact of multiple

environmental factors on species abundance in various forest layers using an integrative modeling approach. *Global Ecology and Conservation*, *29*, e01712. https://doi.org/10.1016/j.gecco.2021.e01712

Ren, J., Su, K., Zhou, Y., Hou, Y., & Wen, Y. (2022). Why Return? Birdwatching Tourists' Revisit Intentions Based on Structural Equation Modelling. *Sustainability*, *14*(21), 14632. https://doi.org/10.3390/su142114632

Rodriguez, P. S., Schwantes, A. M., Gonzalez, A., & Fortin, M.-J. (2024). Monitoring Changes in the Enhanced Vegetation Index to Inform the Management of Forests. *Remote Sensing*, *16*(16), 2919. https://doi.org/10.3390/rs16162919

Romero, J. E. C., González, E. B., López-Vivas, J. M., Quintana, J. Á. A., Parra, J. A., Felix, E. E. A., & Castillo-Rosas, B. R. (2022). Determination of the Taxonomic Diversity of the Intertidal Fish Communities on the Pacific Coast of Baja California Sur, México from 2015-2019. *Open Journal of Marine Science*, *12*(02), 44–60. https://doi.org/10.4236/ojms.2022.122004

Roswell, M., Dushoff, J., & Winfree, R. (2021). A conceptual guide to measuring species diversity. *Oikos*, *130*(3), 321–338. https://doi.org/10.1111/oik.07202

Rozi, I. E., Permana, D. H., Syahrani, L., Asih, P. B. S., Zubaidah, S., Risandi, R., Wangsamuda, S., Dewayanti, F. K., Demetouw, M. R., Mabui, S., Robaha, M. M. F., Sumiwi, M. E., Bangs, M. J., Lobo, N. F., Hawley, W. A., & Syafruddin, D. (2024). Rapid entomological assessment in eight high malaria endemic regencies in Papua Province revealed the presence of indoor and outdoor malaria transmissions. *Scientific Reports*, *14*(1), 14603. https://doi.org/10.1038/s41598-024-64958-w

Saeedi, H., Warren, D., & Brandt, A. (2022). The Environmental Drivers of Benthic Fauna Diversity and Community Composition. *Frontiers in Marine Science*, *9*, 804019. https://doi.org/10.3389/fmars.2022.804019

Sayuti, R. H. (2023). Community Readiness in Implementing Sustainable Tourism on Small Islands: Evidence from Lombok, Indonesia. *Sustainability*, *15*(12), 9725. https://doi.org/10.3390/su15129725

She, Y., Li, X., Li, C., Yang, P., Song, Z., & Zhang, J. (2023). Relationship between Species Diversity and Community Stability in Degraded Alpine Meadows during Bare Patch Succession. *Plants*, *12*(20), 3582. https://doi.org/10.3390/plants12203582

Storch, F., Boch, S., Gossner, M. M., Feldhaar, H., Ammer, C., Schall, P., Polle, A., Kroiher, F., Müller, J., & Bauhus, J. (2023). Linking structure and species richness to support forest biodiversity monitoring at large scales. *Annals of Forest Science*, *80*(1), 3. https://doi.org/10.1186/s13595-022-01169-1

Suana, I. W., Ahyadi, H., Hadiprayitno, G., Amin, S., Kalih, L. A. T. T. W. S., & Sudaryanto, F. X. (2020). Environment carrying capacity and willingness to pay for bird-watching ecotourism in Kerandangan Natural Park, Lombok, Indonesia. *Biodiversitas Journal of Biological Diversity*, *21*(5). https://doi.org/10.13057/biodiv/d210557

Thukral, A. K., Bhardwaj, R., Kumar, V., & Sharma, A. (2019). New indices regarding the dominance and diversity of communities, derived from sample variance and standard deviation. *Heliyon*, *5*(10), e02606. https://doi.org/10.1016/j.heliyon.2019.e02606

Torresani, M., Rossi, C., Perrone, M., Hauser, L. T., Féret, J.-B., Moudrý, V., Simova, P., Ricotta, C., Foody, G. M., Kacic, P., Feilhauer, H., Malavasi, M., Tognetti, R., & Rocchini, D. (2024). Reviewing the Spectral Variation Hypothesis: Twenty years in the tumultuous sea of biodiversity estimation by remote sensing. *Ecological Informatics*, *82*, 102702. https://doi.org/10.1016/j.ecoinf.2024.102702

Triyadi, A., & Toni, H. (2023). Floristic diversity and threats in new hilly tourist areas: A case study in the Riam Setongah nature tourism area, Lamandau Regency. *IOP Conference Series: Earth and Environmental Science*, *1253*(1), 012120. https://doi.org/10.1088/1755-1315/1253/1/012120

Trogisch, S., Liu, X., Rutten, G., Xue, K., Bauhus, J., Brose, U., Bu, W., Cesarz, S., Chesters, D., Connolly, J., Cui, X., Eisenhauer, N., Guo, L., Haider, S., Härdtle, W., Kunz, M., Liu, L., Ma, Z., Neumann, S., … Bruelheide, H. (2021). The significance of tree-tree interactions for forest ecosystem functioning. *Basic and Applied Ecology*, *55*, 33–52. https://doi.org/10.1016/j.baae.2021.02.003

Uddin, M. M., Schneider, P., Asif, Md. R. I., Rahman, M. S., Arifuzzaman, & Mozumder, M. M. H. (2021). Fishery-Based Ecotourism in Developing Countries Can Enhance the Social-Ecological Resilience of Coastal Fishers—A Case Study of Bangladesh. *Water*, *13*(3), 292. https://doi.org/10.3390/w13030292

Uhl, B., Schall, P., & Bässler, C. (2024). Achieving structural heterogeneity and high multi-taxon biodiversity in managed forest ecosystems: A

European review. *Biodiversity and Conservation*. https://doi.org/10.1007/s10531-024-02878-x

Vu Ho, K., Ćuk, M., Šikuljak, T., Kröel-Dulay, G., Bátori, Z., Tölgyesi, C., Fűrész, A., Török, P., Hábenczyus, A. A., Hegyesi, A., Coşgun, Z. L., & Erdős, L. (2023). Forest edges revisited: Species composition, edge-related species, taxonomic, functional, and phylogenetic diversity. *Global Ecology and Conservation*, *46*, e02625. https://doi.org/10.1016/j.gecco.2023.e02625

Wambrauw, H. S., Raunsay, E. K., & E. Rehiara, R. (2023). Vegetation Analysis of Target Species for Feeding Lesser Yellow Bird of Paradise (Paradisaea minor jobiensis Rothschild, 1897) in the Imbowiari Forest Area of Barawai Village, Yapen Islands District, Papua Province, Indonesia. *Asian Journal of Natural Sciences*, *2*(2), 97–108. https://doi.org/10.55927/ajns.v2i2.4182

Waroy, H. F., Utami, S., & Jumari. (2020). The food plant ethnobotany of Ampari tribe community in Papua, Indonesia. *Journal of Physics: Conference Series*, *1524*(1), 012074. https://doi.org/10.1088/1742-6596/1524/1/012074

Wazaraka, Z. A., Raunsay, E. K., & Kameubun, K. M. B. (2019). The Availability of the Basic Vegetation Materials for the Bird Nest of Paradisaea minor jobiensis in Yapen, Islands Papua. *Jurnal Sylva Lestari*, *7*(2), 174. https://doi.org/10.23960/jsl27174-185

Weisser, W. W., Roscher, C., Meyer, S. T., Ebeling, A., Luo, G., Allan, E., Beßler, H., Barnard, R. L., Buchmann, N., Buscot, F., Engels, C., Fischer, C., Fischer, M., Gessler, A., Gleixner, G., Halle, S., Hildebrandt, A., Hillebrand, H., De Kroon, H., … Eisenhauer, N. (2017). Biodiversity effects on ecosystem functioning in a 15-year grassland experiment: Patterns, mechanisms, and open questions. *Basic and Applied Ecology*, *23*, 1–73. https://doi.org/10.1016/j.baae.2017.06.002

Wohlgemuth, D., Solan, M., & Godbold, J. A. (2016). Specific arrangements of species dominance can be more influential than evenness in maintaining ecosystem process and function. *Scientific Reports*, *6*(1), 39325. https://doi.org/10.1038/srep39325

Yan, H., Li, F., & Liu, G. (2023). Diminishing influence of negative relationship between species richness and evenness on the modeling of grassland α-diversity metrics. *Frontiers in Ecology and Evolution*, *11*, 1108739. https://doi.org/10.3389/fevo.2023.1108739

Zhang, R., Tian, D., Wang, J., & Niu, S. (2023). Critical role of multidimensional biodiversity in contributing to ecosystem sustainability under global change. *Geography and Sustainability*, *4*(3), 232–243. https://doi.org/10.1016/j.geosus.2023.05.002

Zhao, Z., Hui, G., Yang, A., Zhang, G., & Hu, Y. (2022). Assessing tree species diversity in forest ecosystems: A new approach. *Frontiers in Ecology and Evolution*, *10*, 971585. https://doi.org/10.3389/fevo.2022.971585