Health Assessment Of Conservation Forest-Based On Biodiversity Indicator Tree Types (Case Study at Elephant Respont Unit Margahayu Way Kambas National Park)

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Abstract. Conservation forest health assessment based on indicators of tree diversity is needed because it is sensitive to changes, indicators of ecological systems, spatial, temporal, and trophic heterogeneity. This study aims to determine the variety of tree species in Margahayu Elephant Response Unit Way Kambas National Park as an indicator of forest health assessment. The research was conducted using the Forest Health Monitoring method. The area of Margahayu Elephant Response Unit in Way Kambas National Park is 35.2 ha. One cluster plot has an area of 0.4 ha, so the number of research clusters created in this study is 5 clusters with a total area of 2 ha of observational collections. The results showed that the final value of forest health status with indicators of biodiversity (tree species diversity) in Margahayu Elephant Response Unit Way Kambas National Park was in the excellent category of 20% in cluster plot 2, while 60% in cluster plots (3, 4, and 5), and 20% poor in cluster plot 1, thus indicating that the forest in the Margahayu Elephant Response Unit Way Kambas National Park is in a reasonably healthy (stable) condition with a moderate category.

1. Introduction
Geographically, Way Kambas National Park is located in East Lampung Regency, Lampung Province. Way Kambas National Park is a habitat for nearly 200 Sumatran elephants (*Elephas maximus sumatranus*) or 10% of the total remaining population, estimated to be no more than 2000 individuals [1]. The Elephant Response Unit (ERU) was established in 2011 in Way Kambas National Park, one of which is the Margahayu ERU located at RPTN Margahayu SPTN III Kuala Penet. Conflicts between elephants and humans occur, especially in buffer villages around Way Kambas National Park. One of the efforts to resolve this conflict was establishing the ERU at Way Kambas National Park (WKNP). ERU Margahayu has 35.2 ha, which is a habitat for animals and plants in WKNP. The condition of the ERU Margahayu area has low land cover due to land clearing by the community around the forest in 2006 which was then reforested with sonokeling tree species. To realize forest sustainability for both animals and plants at ERU Margahayu, the condition of the forest must be healthy.

The condition of biodiversity or biodiversity is an essential thing for ecosystems in conservation forests [2]. Biodiversity acts as an indicator and a means to determine changes in forest ecosystems [3]. Biodiversity also includes species richness and ecosystem complexity so that it affects the organism community, development, and ecosystem stability [4].

According to [5], forest health can be used as an illustration to determine the condition of a forest ecosystem that is carrying out its primary function well. Forest biodiversity parameters have been
used as criteria for the sustainability of forest ecosystems [6]. The tree species biodiversity parameter is one of the vital ecological indicators for the health of Indonesia’s tropical rainforests [7]. According to [8, 9], there are four critical environmental indicators for the health of Indonesia’s tropical rainforests, namely: productivity, vitality, site quality, and biodiversity (species diversity). Assessment of biodiversity parameters is critical to do so that the complexity of a species in a particular forest ecosystem can be determined by knowing the composition of the flora contained therein [10].

The higher the number of tree species and the value of tree species diversity in an area will also increase ecological functions. Forest management in ERU Margahayu WKNP needs to be conducted research related to the health of the forest because it is located in a conservation forest area. The level of biodiversity with tree species diversity is closely related to ecological stability in an ecosystem. Thus, it is imperative to research to determine the health condition of conservation forests in ERU Margahayu WKNP by using ecological indicators based on biodiversity.

2. Materials and Methods

2.1. Research Time and Location
The research was conducted from November to December 2020 at ERU Margahayu Way Kambas National Park, East Lampung Regency. Map of forest health research locations can be seen in Figure 1.

Figure 1. Map of health analysis research locations at ERU Margahayu Way Kambas National Park with a scale of 1:200,000
2.2. Tools and Materials

The tools and materials used in this research are GPS (Global Positioning System), 50 m meter, tape measure, machete, hoe, digital camera, calculator, ruler, plastic, tally sheet, stationery, and practicum manual. Forest Health [11]. The materials or objects used are tree species and soil samples in the Forest Health Monitoring (FHM) plot cluster in ERU Margahayu Way Kambas National Park.

2.3. Data retrieval

This study uses a sampling intensity of 5%. This is based on P.67/Menhut-II/2006 concerning Forest Inventory Criteria and Standards, that in using the method of measuring circle, rectangle, point, and path, the minimum sampling intensity is 0.0025%. The total area of the Margahayu ERU in Way Kambas National Park is 35.2 ha. One cluster-plot has an area of 0.4 ha, so the number of research clusters created in this study is 5 clusters with a total area of 2 ha of observational clusters. Creating a plot cluster or measuring plot means taking several objects that represent the entire observed area [12]. The cluster-plot design is based on reference to the FHM technique [13]. One plot caster is known to have a place of 4,046.86 m², representing one (1) ha forest area [14]. Some of the criteria for making FHM plot clusters are:

- It's not an indirect plot as a circle with a range of 17.95 m and a subplot of 7.32 m.
- The focus point of subplot 1 (one) is the central place of the entire plot. The middle mark of subplot 2 (two) is situated toward 0° or 360° from the middle mark of subplot 1 (one), the centre mark of subplot 3 (three) is located 120° from the focus point subplot 1 (one), and the centre of subplot 4 (four) is located in the direction of 240° from the central area of subplot 1, with each distance between the centres of subplots is 36.6 m.
- Three soil sample points define each cluster plot. Soil sample point 1 is located in the direction of 00 or 360° from the centre point of subplot 1, soil sample point 2 lies in the order of 1200 from the centre point of subplot 1, soil sample point 3 is located in the direction of 2400 from the centre point of subplot I, with a distance of 18 each m.
- The plot cluster consists of 4 annular plots, subplots, and micro plots.

![Figure 2. FHM plot cluster design](image-url)
2.4. Data analysis
Data processing and analysis were carried out on the measurement results of tree species diversity at the research location. The level of species diversity is determined using the Shannon-Wiener index $H'$ formula [15].

$$H' = \sum p_i \ln p_i$$

Information:
$H' = $ Shannon-Wiener Index
$pi = ni / N$
$ni = number of individuals of type i$
$N = number of individuals of all species$

The criteria for the diversity index value are as follows. $H'<1$ (vegetation communities with less stable environmental conditions); $1 < H' < 3$ with very stable environmental conditions).

2.5. Forest Health Assessment
Measurement of forest health uses indicators of biodiversity with parameters of tree species diversity [16]. The data obtained were used to determine the health status of the forest as measured by FHM. The formula used for the final forest health value [5] is:

$$NKH = NT \times NS$$

Note $NKH = $ final value of forest health condition; $NT = $ weighted value of tree species diversity parameters; $NS = $ the worth of the varietal limit scores for tree species.

3. Results and Discussion
In carrying out conservation forest management, it is essential to know forest health assessment [17]. Assessment of biodiversity indicators is necessary to see the complexity of a species in the conservation forest ecosystem by knowing the composition of the flora contained in it [18]. The diversity assessed is the diversity that meets the threshold according to predetermined provisions [19]. The level of diversity (biodiversity) is directly proportional to the level of flexibility, where the higher the level of biodiversity in a forest, the more resilient the forest will be [20].

Forest health assessment using biodiversity indicators is carried out by measuring tree species diversity using the Shannon–Wiener index formula [21]. Tree species diversity measurements were carried out on trees in the annular plot. The tree species diversity index is an index that states the structure of a community so that the better the species diversity index, the more stable an ecosystem will be [22]. The highest biodiversity value is 0.76 in cluster plot 2, and the lowest is 0.15 in cluster plot 1. The assessment of the diversity index for tree species in each plot cluster can be seen in Table 1.

| Cluster Plot | $H'$   |
|--------------|--------|
| 1            | 0.15   |
| 2            | 0.76   |
| 3            | 0.45   |
| 4            | 0.44   |
| 5            | 0.51   |

Source: Primary Data (2020).

Conservation forest located in ERU Margahayu WKNP must carry out sustainable management without changing the status and function of the forest area. Forest health assessment in conservation forest areas in the ERU Margahayu WKNP can be assessed through the diversity of tree species identified as criteria for the sustainability of the forest ecosystem. This study’s assessment of diversity (biodiversity) uses a diversity index with the Shannon-Weiner Index formula [23].
After calculating the five plot clusters, the diversity values were obtained for each plot cluster, as in Table 1. The lowest H’ values and the highest H’ values were found in cluster plot 1 (one) and cluster plot 2 (two), namely 0.15 and 1. 76,[16], H’<1.5 indicates low species diversity if H’ = 1.5-3.5 indicates moderate species diversity and H’> 3.5 indicates high species diversity. Based on this, the plot cluster in the ERU Margahayu WKNP shows that the level of species diversity is low in cluster plots 1, 2, 3, 4, and 5.

According to Shannon-Wiener [24], if the value of H’<1, then the vegetation community with less stable environmental conditions; if the H’ value is between 1-2, then the vegetation community with harsh environmental conditions; if the value of H’> 2, then the vegetation community with environmental conditions is very stable. The cluster plots (1, 2, 3, 4 and 5) show vegetation communities with less demanding ecological conditions because the H’obtained is <1.

Based on the research results, from all five plot clusters, seven species of trees were obtained. The following data on tree species diversity in the cluster plot in the ERU Margahayu WKNP can be seen in Table 2.

### Table 2. Tree Species Diversity Data

| No | Types of Trees | Latin Name               | Amount | Plot               |
|----|----------------|--------------------------|--------|--------------------|
| 1  | Sonokeling     | *Dalbergia lativolia*    | 51     | 1,2,3,4,5          |
| 2  | Kandri         | *Bridelia monoica*       | 18     | 1, 2, 5            |
| 3  | Salam          | *Syzygium polyanthum*    | 2      | 2                  |
| 4  | Mentru         | *Schima wallichii*       | 6      | 2 & 3              |
| 5  | Akasia         | *Acacia mangium*         | 1      | 2                  |
| 6  | Cempaka        | *Magnolia champaca*      | 2      | 3 & 5              |
| 7  | Laban          | *Vitex pinnata*          | 11     | 4                  |

Amount 91

Source: Data Primer (2020).

In Table 2, it can be seen that the types of plants are dominated by Sonokeling (*Dalbergia latifolia*) with 51 stems, Kandri (*Bridelia monoica*) with 18 branches and Laban (*Vitex pinnata*) with 11 stems. There are also three species with the least number: Acacia (*Acacia mangium*), which has only one trunk.

### Table 3. Value of Tree Species Diversity Parameter Score

| Score | Species Diversity Class (H’)          |
|-------|---------------------------------------|
| 1     | 0.15 - 0.20                           |
| 2     | 0.21 - 0.26                           |
| 3     | 0.27 - 0.32                           |
| 4     | 0.33 – 0.38                           |
| 5     | 0.39 – 0.45                           |
| 6     | 0.46 -0.51                            |
| 7     | 0.52- 0.57                            |
| 8     | 0.58 – 0.63                           |
| 9     | 0.64 – 0.69                           |
| 10    | 0.70 – 0.76                           |

Source: Data Primer (2020).

After obtaining the diversity value, the score was determined for each cluster plot. As presented in Table 3. [25], stated that the biodiversity indicator was chosen because it is sensitive to change, can be an indicator of the ecological system, and experiences spatial, temporal, and trophic heterogeneity. Biodiversity data in the form of species diversity obtained from direct data collection in each plot...
cluster. Biodiversity data is needed to measure the flexibility level of a species in a particular ecosystem [26].

The highest score is shown in Table 3, 6, with a class value of 0.46-0.51. Meanwhile, the lowest score is 1, with a value of 0.15 - 0.20. The high and low score values of the ecological indicator parameters of species diversity will affect the final value of the forest health condition obtained [27]. The higher the score obtained, the higher the forest health level [28]. The last forest health value is obtained from the multiplication of the score for each plot cluster with the weighted value [29]. The threshold values for forest health status in the Margahayu WKNP ERU and the final forest health values results are shown in Tables 4 and 5.

| No | Category | Clas Score |
|----|----------|------------|
| 1  | Good     | 3.37 – 4.80|
| 2  | Moderate | 1.93 – 3.36|
| 3  | Bad      | 0.48 – 1.92|

Source: Data Primer (2020).

| Cluster Plot | Forest Health Final Value (NKH) | Category |
|--------------|---------------------------------|----------|
| 1            | 0.48                            | Bad      |
| 2            | 4.80                            | Good     |
| 3            | 2.40                            | Moderate |
| 4            | 2.40                            | Moderate |
| 5            | 2.88                            | Moderate |

Source: Data Primer (2020).

The results show that the forest in ERU Margahayu WKNP has a level of tree species diversity, namely four plot clusters showing vegetation communities with stable environmental conditions and one plot cluster showing vegetation communities with less demanding environmental conditions Shannon-Wiener [30]. Forest health condition categories are obtained based on the final score. The absolute value of forest health in ERU Margahayu WKNP was 4.80, and the lowest was 0.48. This forest health condition category shows that out of 5 plot clusters, there is still one plot cluster with a wrong variety. This bad category indicates the low tree species diversity in the plot cluster. So it still needs proper and intensive management so that the health status of forests in arable areas can increase and improve. Based on table 5, the healthiest forest health condition is in cluster plot 2, which has the highest final value, namely 4.80 in the excellent category. On the other hand, the worst forest health condition is in cluster plot 1 with the lowest absolute value, namely 0.48. From the results of the data obtained, it can be categorized that the health condition of the forest in ERU Margahayuis presented in Figure 2.
Conservation forest in Eru Margahayu TNWK which is in the moderate criteria is affected by one of the ecological indicators of forest health being low. The parameter of the ecological indicator of the health of the conservation forest is biodiversity or a low index of tree species diversity. According to [30] one of the scopes of biodiversity is species diversity so that high diversity will result in stable environmental stability. In order for the health condition of the conservation forest in Eru Margahayu TNWK to be healthy, it is necessary to replant trees which will allow the increase in the diversity of tree species in Eru Margahayu.

4. Conclusion
The final value of forest health status with indicators of biodiversity (diversity of tree species) ERU Margahayu TNWK is in the medium criteria.

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