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Analysis of Changes in Forest Health Status Values in Conservation Forest (Case Study: Plant and Animal Collection Blocks in Wan Abdul Rachman Forest Park (Tahura WAR))

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Abstract. Data and information on the health condition of conservation forests can be obtained by periodically monitoring forest health. Forest health monitoring is intended to monitor, assess, and report on the current status, changes and long-term trends in the health of forest ecosystems. This study aims to obtain changes in the value of the status of conservation forest conditions. The location of this research is in the Wan Abdul Rachman Forest Park (Tahura WAR) in the plant and animal collection block area. This study used the Forest Health Monitoring (FHM) method with a sample measuring plot in the form of six FHM clusters. The stages of this research are making measuring plots, monitoring forest health, and assessing the health of conservation forests. The results showed that the change in the value of the status of the health condition of conservation forests was that the cluster plots 1, 2, and 5 had changed and the cluster plots 3, 4, and 6 did not change. Thus there is a change in the value of the health status of conservation forests which tends to be better.

1. Introduction

Conservation forest is a forest area with certain characteristics, which has the main function of preserving plant and animal diversity and its ecosystem. Wan Abdul Rachman Forest Park (Tahura WAR) is a conservation area based on a decree given by the government. Tahura is a nature conservation area for the purpose of collecting natural or artificial plants and / or animals, native and / or non-native species, which are used for the purposes of research, science, education, support for culture, culture, tourism and recreation (UU No. 5 tahun 1990). The Tahura WAR area is divided into three blocks, one of which is the Plant and Animal Collection block.

On the other hand, a forest is said to be healthy if the forest can still fulfill its function as a predertemined main function (Nuhamara et al., 2001). One way to determine the health condition of a conservation forest ecosystem is to periodically monitor of forest health. Forest health is a method used to monitor, assess and report on the status, changes, and current trends that occur in long-term forest health using measurable ecological indicators (Mangold, 1997).

For this reason, it is necessary to know the changes in the value of the health status of conservation forests. Especially the Plant and Animal Collection Block in Tahura WAR, so that the function of preserving plant and animal diversity and the ecosystem in the conservation forest area is maintained.

2. Literature Review

Brief describtion of forest health monitoring and conservation forests. Summary descriptions in the form of scientific knowledge information from various literatures, such as: books, journals, articles, and other supporting scientific information.

2.1. Forest Health Monitoring

Data and information on forest health conditions can be obtained by periodically monitoring forest health. Forest Health Monitoring (FHM) is designed to monitor forest health conditions based on the measurement results of predetermined ecological indicators. Data and information on the condition of the ecological indicators for forest health are continuously collected and monitored. According to Mangold (1997); USDA-FS (1999) FHM is a method for monitoring, assessing and reporting on the current status, changes, and long-term trends of forest ecosystem health using measurable ecological indicators. The assessment of these ecological indicators can describe forest conditions in a comprehensive manner. According to Safe'i and Tsani (2016) forest health monitoring is an effort to determine the status, changes and trends that occur with regard to the condition of a forest ecosystems at a certain time and are assessed based on the objectives and functions of a forests and forest areas. According to Haikal et al. (2020), this FHM program aims to determine current forest conditions, future changes and trends that may occur due to activities that have been carried out in the forest.

The FHM program was first implemented in 1992 by the USDA-FS in collaboration with the US-EPA which was designed to monitor forest conditions in all forest areas in the United States. The FHM program emerged because of the increasing need for forest health information due to concerns that climate change could cause new types of damage that had not been discovered before (Wullf et al., 2013).

The FHM program is expected to be able to explain changes in forest conditions that occur at certain times to address forest health problems that have an impact on the preservation of forest ecosystems. Therefore, the ultimate goal of this program is to answer a series of "What, where, when, how and why" questions about forest health (Mangold 1997; USDA-FS 1999). In this regard, the FHM system takes an approach through three interrelated components related to the health condition of all forests in the United States in detail. The three components, namely: detection monitoring, evaluation monitoring, and monitoring of the location ecosystem intensively.

As such, the FHM program is widely recognized in sub-tropical forests, which are characterized by slow growth, low biodiversity, and little pest infestation. Especially in tropical forests which have the characteristics of high productivity and high biodiversity, closed nutrient cycles, and stable micro-climate conditions, Indonesia is the first country to apply the FHM method. The FHM method in Indonesia was tested in 1997-2000 by modifying the parameters of pests and diseases, soil fertility and biodiversity (ITTO and SEAMEO BIOTROP 2001).

2.2. Conservation Forest

Conservation Forest is a forest area with certain characteristics that has the main function of preserving plant and animal diversity and its ecosystem. Conservation forest consists of: nature reserve forest areas, nature conservation forest areas, and hunting parks (Law No. 41 of 1999). Nature reserve areas consist of: nature reserve areas and wildlife reserve areas. Nature conservation forest areas, consisting of: national park areas, natural tourism park areas, and grand forest park areas.

Forest Park (Tahura) is a conservation area in the form of a nature conservation area (Safe'i R. et al., 2020). This is in accordance with the definition of Tahura based on Government Regulation of the Republic of Indonesia Number 28 of 2011, namely natural conservation areas for the purpose of collecting natural or non-natural plants and / or animals, native species and / or non-native species,

which are not invasive and used for the benefit of research, science, education, cultivation support, culture, tourism and recreation. The function of the Tahura area is the same as other nature conservation areas, namely:

1. As a protective area for life support systems
2. As an area to preserve plant species diversity
3. As an area for sustainable use of living natural resources and their ecosystems

The management of the Tahura area is delegated to the local government by managing the area in accordance with central government regulations related to forestry in general and conservation in particular. Utilization and use of the Tahura area can be carried out by dividing the area into several management blocks. Management blocks in Tahura include: utilization blocks, plant and animal collection blocks, protection blocks, and other blocks.

Tahura WAR is a Tahura area in Lampung Province and is administratively is located in two areas, namely: Bandar Lampung City and Pesawaran District. Therefore, the Tahura WAR area has an important role for the survival of the community, including as a source of clean water supply, an erosion barrier, a carbon sink, and a source of income for the surrounding community. In addition, the Tahura WAR area also has a role as a habitat for wild plants and animals, especially those protected by the government and international institutions.

The types of vegetation in the Tahura WAR area are divided into two types, namely: primary forest vegetation and agroforestry land. Primary forest vegetation consists of wild plants, while agroforestry land vegetation consists of cultivated plants. Wildlife in the Tahura WAR area consists of the mammals and aves (UPTD Tahura WAR, 2016).

Tahura WAR has three main functions, namely: protection of life support systems, preservation of plant and animal diversity, and sustainable use of living natural resources and their ecosystems. The protection function of life support systems is focused on protection and rehabilitation blocks, the function of preserving plant and animal diversity is more focused on the collection blocks of plants and animals, the function of sustainable use is more focused on social forestry blocks.

3. Research Methodology

This research was conducted in the plant and animal collection block of the Tahura WAR. The tools used include: meter, tallysheet, digital camera, tape meter, compass, Global Positioning System (GPS), tacks, mica paper, permanent markers, pipe pipes, magic cards, and manuals. The stages of this research include:

3.1. Making Measuring Plots

Making measuring plots based on the FHM plot cluster design (Mangold, 1997; USDA-FS, 1999). Six cluster plot clusters were designed.

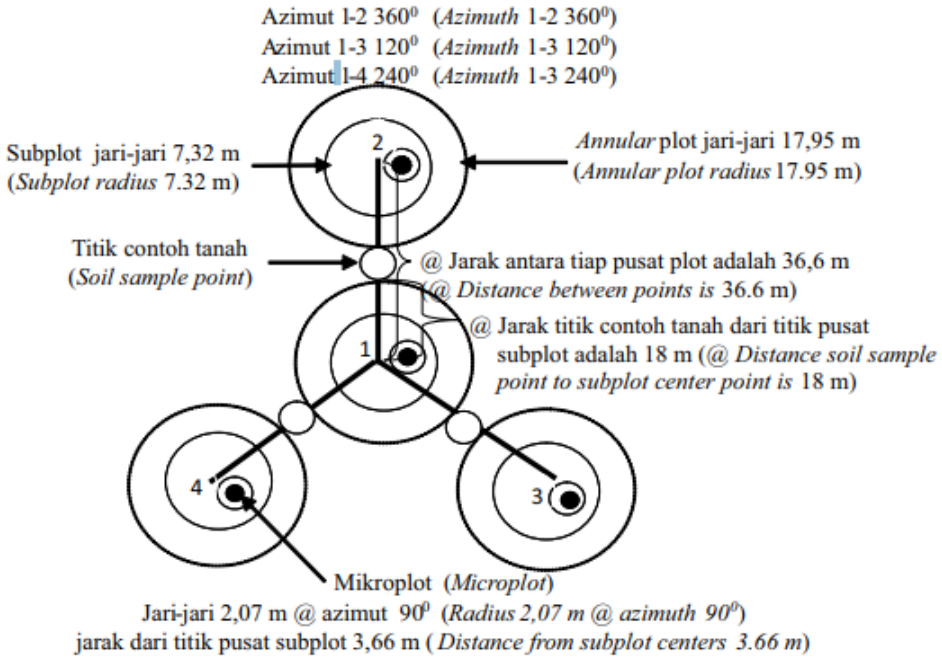

Figure 1. FHM cluster-plot design.

3.2. Forest Health Monitoring

Forest health monitoring is carried out by measuring forest health based on ecological indicator parameters of conservation forest health, including: biodiversity (tree species diversity), vitality (tree damage and canopy conditions), and site quality (soil acidity). Forest health measurements were carried out twice the measurement time. Measurement of parameters for ecological indicators of conservation forest health are as follows:

a. Biodiversity is calculated based on the species diversity index or diversity index using the Shannon-Weiner Index calculation formula, namely: H '= -Σ pi ln pi (Kent and Paddy, 1992).
b. Vitality is obtained based on tree and canopy damage conditions, tree damage conditions are calculated based on the tree damage index value at the cluster plot level (Cluster plot Level Index-CLI) (Nuhamara et al, 2001). Canopy conditions were obtained from combining 5 (five) canopy condition parameters (Nuhamara and Kasno, 2001), which includes live crown ratio (LCR), crown density (the amount of light that can be blocked by the trees canopy to reach the forest floor) (Crown Density-Cden), canopy transparency (Foliage Transparency-FT), horizontal crown diameter (Crown Diameter Width-CDW), vertical crown diameter (Crown Diameter at 90^0-$CD90^0$) and dieback-CDB. After assessing the five parameters, the visual crown ratio (VCR) value will be obtained (Darmansyah, 2014).
c. Site quality is obtained from soil pH value data from soil analysis in soil laboratory. The degree of acidity (pH) of the soil is a feature or parameter used to indicate the acid-base state in the soil (Damanik, 2010). The pH value ranges from 0 to 14. A solution is said to be neutral if it has a pH value = 7. A pH value> 7 indicates an alkaline solution, while a pH value <7 indicates acidity. The measurement technique is that each soil sample in each cluster-plot to measure for soil pH using a pH meter by first mixing the soil samples to be measured with a certain amount of water.

3.3. Forest Health Assessment

Forest health assessment is carried out on the results of the 1st and 2nd measurements of the ecological indicator parameters of conservation forest health. Conservation forest health assessments are carried out using the Forest Health Assessment Information System (SIPUT) software.

4. Result and Discussions

Conservation forest health monitoring was carried out twice the time measured by the FHM method (Safe'i R. et al, 2020). The results of the conservation forest health assessment in two times the measurement of the ecological indicator parameters for the health of the conservation forest health using the SIPUT software are described below.

4.1. Biodiversity Indicator Assessment

Assessment of biodiversity indicators is needed in measuring the flexibility of a species in a particular forest ecosystem. Biodiversity indicators can be assessed using the tree species diversity index (Safe'i et al., 2019). The results of the tree species diversity index assessment in each cluster-plot can be seen in Table 1.

Table 1. Species diversity index value of the first and second measurements in the FHM cluster-plot conservation forest

Cluster-plot FHM	1st H' measurement	2nd H' measurement	Change
1	0.76	0.76	0.00
2	1.01	1.01	0.00
3	0.89	0.89	0.00
4	1.55	1.55	0.00
5	1.22	1.22	0.00
6	0.76	0.76	0.00

Source: Processed from field data

H': index species diversity

Assessment of biodiversity indicators is needed in measuring the degree of flexibility of a species in a particular forest ecosystem. Biodiversity indicators can be assessed using the tree species diversity index. Assessment of biodiversity in this study uses a diversity index with the Shannon-Weiner Index formula (Kent and Paddy, 1992). Tree diversity index shows the relationship between the number of species and the number individuals that form a community (Heddy, 1994). Table 1 shows that there is no change in the value of biodiversity in each plot. Based on the results of research on the six cluster-plots, 20 tree species were obtained. The plants that dominate are Durian (*Durio zibethinus*) with 31 trees and Melinjo (*Gnetum gnemon*) with 25 trees.

The results showed that the six cluster-plots in Tahura WAR showed low to moderate diversity. The results of the study do not show a high level of diversity, which causes changes in land cover from forest to non-forest conditions and resulted in decreased biodiversity. Therefore, it is necessary to make efforts to increase its diversity, because high tree diversity will help forests maintain the ecological balance of their environment (Safe'i et al., 2019).

Tree diversity often affects tree growth positively (Fichtner et al., 2018) and the temporal stability of primary productivity (Hutchison et al., 2018). These ecosystem function effects on biodiversity have been linked to mechanisms such as niche differentiation, increased resource use efficiency due to interactions between species ("complementarity effects") or selection and dominance of species with certain traits in the mix ("selection effects") (Loreau and Hector, 2001).

4.2. Vitality Indicator Assessment

Vitality is carried out by measuring the condition of tree damage and the condition of the canopy (Safe'i et al., 2019). Tree vitality is a very influential factor on tree growth, so if inoptibility occurs it can affect the quantity and quality of processed wood that will be produced (Putra et al., 2010).

4.2.1. Tree Damage Conditions

Assessment of tree damage conditions can be determined by the value of tree damage at the cluster-plot level (Cluster plot Level Index-CLI) of 6 cluster-plots. The measurement of tree damage was carried out by observing three tree damage. First, observing the location of tree damage from the bottom (roots) to the top (shoots). Second, observing the types of tree damage based on the types of damage (Mangold, 1997; Safe'i R. at al, 2020). The types of tree damage found in collection blocks of plant and animal Tahura WAR cluster-plots included resinosis, open wounds and wrinkles and damage to leaves, shoots or shoots. Third, calculate the threshold value / level of tree damage based on the damage suffered by trees (Pertiwi et al., 2019).

Table 2. CLI value of the first and second measurements in the FHM cluster-plot conservation forest

Cluster-plot FHM	1st CLI measurement	2nd CLI measurement	Change
1	2.61	2.20	-0.41
2	2.87	3.17	0.30
3	2.16	2.63	0.47
4	1.56	1.80	0.24
5	1.99	2.94	0.95
6	3.51	3.67	0.16

Source: Processed from field data

CLI: Cluster plot Level Index

After the three assessment steps are carried out in the field, then calculating the tree level damage index (TLI), plot level damage index (PLI) and cluster plot level damage index (CLI) are calculated, which is are the cluster-plot level damage index and is the last assessment in the tree damage assessment. The CLI value of each cluster-plot above is obtained by calculating through the Sistem Informasi Pemantauan Kesehatan Hutan (SIPUT) application so that the lowest CLI value is in cluster plot 4 and the highest is in cluster plot 6. The results of measuring tree damage conditions from the cluster-plot are shown in Table 2.

Based on Table 2, the smallest change of CLI value is in cluster-plot 1, which is -0.41. The level of tree damage in all cluster-plots tends to increase. This can be caused by biotic and abiotic factors. Damage to trees due to biotic and abiotic factors can be seen physically, namely the tree organs experience abnormalities or the presence of disturbing organisms. Noviady and Rivai (2015) state that tree damage that occurs can be caused by disease, pest attacks, weeds, fire, weather, animals or due to human activities.

Safe'i and Tsani (2017), the causes of tree damage can be identified and evaluated, then suppressed as early as possible before major damage occurs and the condition gets worse. Pest and disease damage can be treated with insecticides and fungicides to reduce the population of pests and tree destroying disease.

Figure 2. Tree trunk damage in the form of resinosis.

Figure 2 shows one of the damages that occur in trees, namely resinosis. This damage was initially caused by cancer in the tree trunk which is marked by the presence of a swollen trunk and a dark black color. Then the cancer causes resinosis which is characterized by a clear or brown discharge (Pracaya, 2008).

4.2.2. Condition of the tree canopy

There are five parameters used in measuring the condition of the tree crowns, namely: live crown ratio (LCR - Live Crown Ratio), crown density (the amount of light that can be blocked by the tree canopy to reach the forest floor) (Cden - Crown Density), canopy transparency (amount of sunlight entering the forest floor) (FT - Foliage Transparency), horizontal crown diameter (CDW - Crown DiameterWidth), and vertical crown diameter ($CD90^0$ - Crown Diameter at 90^0) and shoot death (branch death starting with the end of the branch leading to the trunk or base of the living canopy) (CDb - dieback) (Darmansyah, 2014). Through the assessment of these five parameters, the canopy appearance rating (VCR - Visual Crown Ratio) will be obtained (Darmansyah, 2014) as shown in table 3. The VCR value is obtained from the results of calculations using the SIPUT application.

Table 3. VCR value of the first and second measurements in the FHM cluster-plot conservation forest

Cluster-plot FHM	1st VCR measurement	2nd VCR measurement	Change
1	2.98	3.79	0.81
2	3.10	3.60	0.50
3	2.96	3.56	0.60
4	3.19	3.75	0.56
5	2.96	3.72	0.76
6	2.79	3.64	0.85

Source: Processed from field data
VCR: visual crown ratio

Based on Table 3, it is known that there was a change in the VCR value. Significant changes are showed in the cluster-plot 6. The condition of the tree crown will affect the photosynthesis process. Damaged tree canopy will cause the nutrients needed for the photosynthesis process to be blocked or only a little bit is transported to the leaves and other tree parts. In the assessment of forest health, a low VCR value indicates a poor canopy condition and little or not optimal photosynthesis results, while a high VCR value in trees indicates the photosynthesis process is running well and the photosynthetic yield in the form of carbohydrates will be more optimal.

The head is the leafy part of the plant. The size of the canopy describes the general health of the tree. The wide and bushy header represents the fast growth rate. Small canopy rarely indicates a site that does not or does not support growth (such as competition with other trees) or too little humidity or other influences (such as foliar disease or wind storms) (Safe'i, 2017).

High canopy density values indicate that the tree has a lot of leaves available for photosynthesis. A low crown density value indicates that the tree is poor in foliage, thin crowns, or withered canopy caused by damage due to insect and disease attacks or other environmental factors, such as: drought, wind, competition, or soil compaction (Safe'i et al., 2019).

4.3. Site Quality Indicator Assessment

Site quality assessment can be seen from soil fertility based on the pH meter value obtained from the results of soil analysis in each cluster-plot. The results of the soil acidity (pH) assessment in each cluster-plot can be seen in Table 4.

Table 4. pH value of the first and second measurements in the FHM cluster-plot conservation forest

Cluster-plot FHM	1st pH measurement	2nd pH measurement	Change
1	5.00	5.00	0.00
2	5.17	5.17	0.00
3	5.00	5.00	0.00
4	5.00	5.00	0.00
5	5.33	5.33	0.00
6	5.00	5.00	0.00

Source: Processed from field data
pH: soil acidity

Site quality is an important indicator of forest health because it is a measurement that refers to the ability of the site to grow, particularly the soil to support plant growth. Soil fertility is the ability of the soil to provide nutrients needed by plants to support the growth and development (Gintings and Nuhamara, 2001).

Soil fertility in each site is certainly different, this can be caused by various factors, processes, and the main constituent material. The results of the site quality assessment from 1st and 2nd measurement showed there is no change of the pH value (Table 4). Each cluster-plot shows that the 6 cluster-plots have soil pH values ranging from 5.00-5.33. Based on the assessment of soil pH according to Romig et al. (1995), the acquisition of this value indicates that the area has moderate acidity, so that the soil condition is included in the scriteria of being unhealthy.

Forest health categories are obtained from forest health threshold values. Forest health threshold values are obtained based on the highest and lowest values for the final forest health condition. The final forest health condition (NKH) value is the sum of the multiplication of the weighted value and the parameter score value of each forest health indicator. The final value of forest health status can be seen in Table 5.

Table 5. The first and second measurement NKH values in the FHM cluster-plot conservation forest

Cluster-plot FHM	1st NKH measurement	Status	2nd NKH measurement	Status	Change
1	4.39	Poor	6.33	Good	1.94
2	4.34	Poor	5.24	Moderate	0.90
3	3.62	Poor	2.45	Poor	-1.17
4	8.69	Good	7.35	Good	-1.34
5	7.17	Good	5.52	Moderate	-1.65
6	3.52	Poor	3.69	Poor	0.17

Source: Processed from field data

NKH: final values of forest health status

Table 5 shows that the results of the 1st and 2nd measurements concluded that changes in the value and health status of the forest tended to improve. Poor forest health status can be caused by low tree diversity. This is because the lower the value of tree species diversity in an area, the less the diversity of ecological functions will result in a decrease in the level of ecological stability. The final score for the status of forest health conditions in the study location is influenced by the valueof the weight and the score for each parameter of the forest health ecological indicators. The greater the weight value and score value for each parameter of the of forest health ecological indicator, the higher the final value of the forest health condition (Safe'i, 2015).

Poor forest health conditions can also be caused by the low soil pH values and the high tree damage values. Therefore, for the health condition of the forest to be healthy, the tree stands in it must be healthy. If the tree stands are unhealthy, it means that the area has the capacity to support the quality of the site which is not fertile, so it is not able to support optimal growth of the stand.

5. Conclusion

Changes in the value of the status of the health condition of the conservation forest (Block Collection of Plants and Animals Tahura WAR) tend to be in a better direction, namely in plot clusters 1 and 2. Meanwhile, for cluster plots that do not experience changes in the value of conservation forest health status, namely cluster-plots 3, 4, 5, and 6.

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