Health Study of Rhino Feed Trees in Rawa Kidang Restoration

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Abstract—**The Rawa Kidang Restoration is an area designated to plant tree species that rhinos like. Food is planted at the Rawa Kidang Restoration to maintain the rhino population. Knowledge of the importance of tree health is necessary because this can be a guide for rejuvenating or breeding trees attacked by disease or pests. To know the quality of rhino food, you need information about the health of rhino food trees. This research aims to investigate the health of rhino food trees in the Rawa Kidang Restoration. This research uses the Cluster Plot Level Index (CLI) formula to observe and examine canopy conditions and tree damage. The canopy condition parameters consist of five parameters: live crown ratio, density, transparency, diameter, and dieback. The parameters for the tree damage condition are the damage's location, the type I feel, and the level of tree damage. The research results show that the tree health value in cluster plot 1 is 2.35; in plot cluster 2, 2.50; in plot cluster 3, 3.70; and in plot cluster 4, 2.92. So, it can be concluded that the average tree health value in the four plot clusters is in the medium category. The severity of canopy conditions and tree damage can be influenced by surrounding conditions such as sunshine, growing conditions, water, and growing space.**

Keywords—**Tree health; vitality; Rawa Kidang restoration.**

I. INTRODUCTION

Forest health has been defined as producing forest conditions that directly satisfy human needs and by resilience, recurrence, persistence, and biophysical processes that lead to sustainable ecological conditions. Our definitions and understanding of forest health are also dependent on spatial scale. Forest Health Protection (FHP), a part of State, Private, and Tribal Forestry, has over 250 specialists in forest entomology, forest pathology, invasive plants, pesticide use, survey and monitoring, suppression and control, assessment, and applied sciences. FHP provides forest health-related services to protect the forests from insects, disease, and invasive species; develop, promote, and implement integrated pest management; and monitor the status, changes, and trends in indicators of forest health [1]. The Rawa Kidang restoration is one of the restorations in Way Kambas National Park (WKNP). This restoration is part of a program established as a manifestation of the conservation partnership at WKNP. Rawa Kidang Restoration is located in Section III, Kuala Penet, Margahayu Resort, Labuhan Ratu VII Village, Labuhan Ratu District, East Lampung Regency. WKNP is divided into forest zones, conservation zones, utilization zones, core zones, and rehabilitation zones [2]. This restoration is a crisis area due to frequent fires, so this restoration was carried out in the WKNP rehabilitation zone [3]. One of the activities carried out in this restoration is planting tree species that rhinos like. WKNP is an area that is not only useful from an ecological perspective for preserving and protecting biodiversity but also has the potential for useful plants, for example, as food for rhinos [4].

The Sumatran rhino (*Dicerorhinus sumatrensis*) is an animal whose existence is threatened with extinction and is also an endemic animal in the WKNP [5]. This is reinforced by including the Sumatran rhino on the IUCN list as an endangered animal [2], [5]. The number of Sumatran rhinos is around 200 to 300. Th e decline in the rhino population is due to land conversion, habitat loss, encroachment, hunting, and illegal logging. The action that needs to be taken to maintain the existence of rhinos is carrying out in-situ breeding by the Sumatran Rhino Sanctuary (SRS) [6]. To retain the rhinos' population, rhino food is planted at the Rawa Kidang Restoration [7]. One factor in the success of breeding is the availability of sufficient feed. Food is also a limiting factor that ensures the development and breeding of rhinos. Rhino growth will be good if the availability of rhino food is abundant and sufficient. Animals' needs for the food provided must be appropriate in terms of quality and quantity [8]. To

know the quality of rhino food, you need information about the health of the types of trees that rhinos feed on.

The level of richness of fauna and flora species can be achieved by maintaining and managing forest [9]. The richness of biodiversity, both flora and fauna, in Indonesia is very abundant, especially in trees [10]. Trees are a biological component in the forest [11]. Knowledge of the importance of tree health is very much needed because this can be a guide for rejuvenating or breeding trees that are attacked by disease or pests. Tree health assessments are carried out based on one forest health indicator, vitality. Vitality is a value to determine the condition of a tree's strength in facing various environmental threats [12]. Vitality measurement parameters are divided into canopy conditions and tree damage. These parameters can describe the health condition of the tree [7]. By measuring this vitality, this research will help determine the health of the rhino food trees in the Rawa Kidang Restoration. Therefore, to achieve this goal, what are the techniques for assessing the health of rhino food trees in the Rawa Kidang Restoration?

II. MATERIALS AND METHODS

A. Study Area

This research was conducted from January 2022 to February 2022 (30 days) at Rawa Kidang Restoration, WKNP, Labuhan Ratu District, East Lampung Regency, Lampung, Indonesia (Figure 1). Way Kambas National Park was established via Forestry Minister Decree Number 670/Kpts-II/1999, dated August 26, 1999.
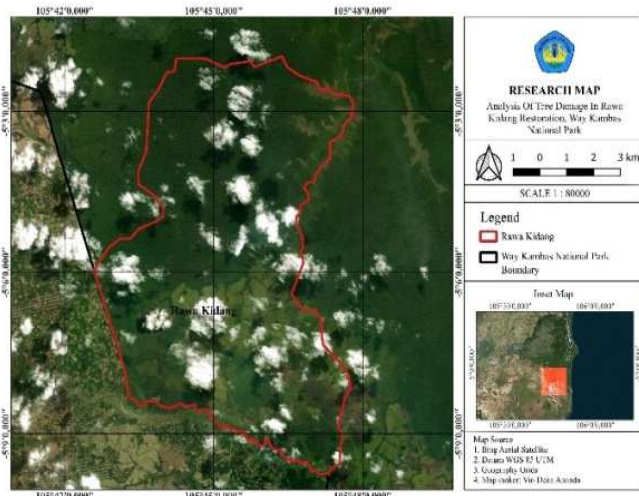

Fig. 1 Research location at Rawa Kidang Restoration

B. Procedures

1) Creating Cluster Plot: The overall or total phase of tree health assessment involves utilizing the Forest Health Monitoring (FHM) method, focusing on ecological indicators such as vitality, which includes canopy condition and tree damage. FHM is a monitoring tool for assessing forest conditions presently and in the future, offering insights for enhancing forest management practices. This technique aids forest managers in implementing principles of forest sustainability [13]. The assessment employs the Forest Health Monitoring cluster plot design for measurements [14]. Four cluster plots were created with a research location area of 20 ha.
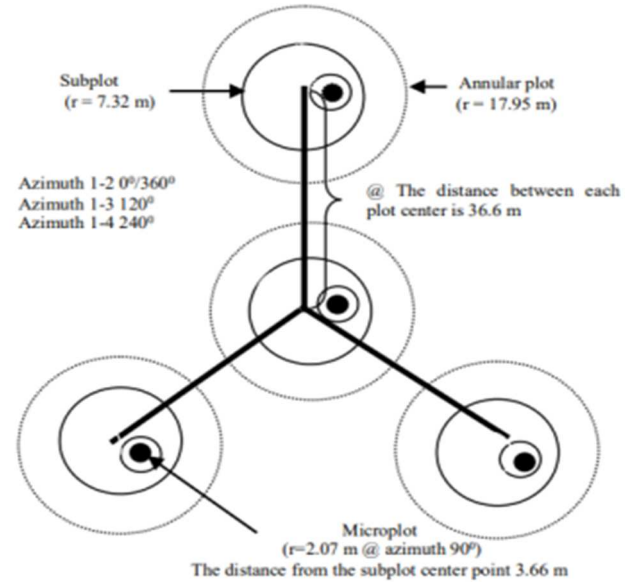

Fig. 2 Cluster plot design according to the Forest Health Monitoring method [15]

2) Tree Health Measurement: Tree health measurements are carried out within sub-plots based on the diameter of trees in the research location <20 cm. Crown condition (VCR) and tree damage (CLI) are assessments of vitality indicators. When assessing tree damage, you need to understand several parameters, namely location damage, type of damage, and severity [16].

3) Data Analysis: The tree damage assessment is based on each damage index (IK), based on the tree (TLI), then proceed with the calculation of the damage index based on the plot (PLI) and damage based on the cluster plot (CLI). The formula used is as follows:

$$IK = x \times y \times z \tag{1}$$

$$TLI = (IK)_1 + (IK)_2 + (IK)_3 \tag{2}$$

$$PLI = \frac{\sum TLI \text{ in the plot}}{\sum \text{trees in the plot}} \tag{3}$$

$$CLI = \frac{\sum PLI}{\sum Plot} \tag{4}$$

Information:
CLI   : Cluster plot level index
PLI   : Plot Level Index
TLI   : Tree Level Index
IK   : Damage Index
(IK) 1,2,3: Damage index 1, 2, and 3
x,y, and z: The weighting value code varies depending on the value of the relativelevel impact of each component on tree growth and resilience.
x   : Location of damage
y   : Damage type
z   : Severity level

The crown conditions are obtained based on five parameters, namely the live crown ratio (LCR), the amount of light that can enter the surface of forest litter/crown density (Cden), foliage transparency (FT), crown diameter width

(CDW), crown diameter 90° (CD90°), and dieback (CDB) [17]. After identifying tree damage and condition, the results are analyzed to determine the final value of tree health using the formula as follows:

$$NKP = \sum (NT \times NS) \tag{5}$$

Information :
NKP   : Final tree health assessment
NT   : The weighted value of each tree health indicator
NS   : Score value for each indicator

The weighted value for tree damage in conservation forests is 0.27, and the weighted value for canopy conditions is 0.22, which is obtained by transforming the values of each parameter of each plot cluster [18].

III. RESULTS AND DISCUSSION

A. Results of Damage Location and Damage Type

The Rawa Kidang Restoration is a restoration area that frequently experiences fires, so the land at that location is barren. The type of tree that dominates the research location is the puspa (*Schima Wallachia*). This type of tree is suitable for planting on critical land due to mining or fire [10]. Tree health assessment, social, and management conditions is needed to formulate management strategies. Defining forest health is a subjective and context-dependent categorization; consequently, several definitions are possible. Forest health is intimately linked to disturbance ecology and the concepts of vitality, resilience, decline, and mortality.

The overall or total phase of tree damage assessment involves evaluating the location and damage type incurred by the tree. Damage location categories include shoots, leaves, crowns, branches, stems, and roots [19]. There were 17 types of damage found by Mangold [15]. According to [6], there are six types of damage were found at the research location. The overall or total phase of the tree damage assessment conducted on the types of rhino food trees indicates that the locations and types of damage sustained by numerous trees at the research location are presented in Figures 3 and 4.
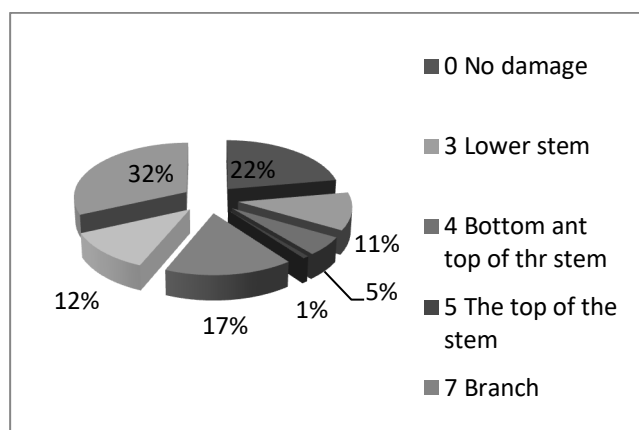
Fig. 3 Number of tree damage locations in Rawa Kidang Restoration
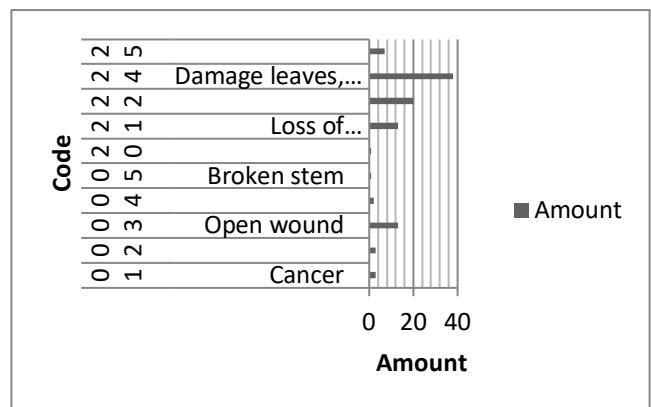
Fig. 4 Number of types of damage in Rawa Kidang Restoration

1) Result of Assessment of Tree Damage and Crown Condition: Poor management is one of the factors that causes tree damage [20]. Tree vitality is an indicator that influences tree growth, so if growth instabilities occur, it can affect the quality and quantity of wood. Tree damage can be assessed by assessing tree damage at the plot cluster level (CLI) in four plot clusters [6], [21]. Tree damage assessment is carried out using three observations, namely, observing the damage on the tree from roots to shoots, observing the type of damage experienced by the tree based on the kind of damage, and calculating the severity of the damage experienced by the tree [22], [12]. Following the damage location, type, and severity assessment, Tree damage conditions were evaluated using the cluster plot rate damage index (CLI), as depicted in Table 1.

TABLE I
CLI VALUE IN CLUSTER PLOTS AT RAWA KIDANG RESTORATION

Cluster Plot	CLI
1	3.17
2	2.64
3	2.23
4	1.42

Note :
CLI: Cluster Plot Level Index

After getting the tree damage value, determine the score value for each plot cluster [23] listed in (Table 2).

TABLE II
CLI PARAMETERS SCORE VALUE

Score Value	Value Range
10	1.42-1.59
9	2.00-2.17
8	2.18-2.35
7	2.36-2.53
6	2.54-2.71
5	2.72-2.89
4	2.90-3.07
3	3.08-3.25
2	3.26-3.43
1	3.44-3.61

The condition of the tree crown is a parameter that illustrates the tree's health. A wide and dense crown shape describes the condition of a crown with good growth, while a small and sparse crown shape describes a canopy with poor growth. This is influenced by growing site conditions that do not support tree growth. According to [24], VCR values illustrate the condition of the tree crwon. If the VCR value is

high, then it can be said that the tree canopy is in good condition, while a VCR value of low value indicates the tree crown is in poor condition [25]. VCR is determined based on five parameters: live crown ratio, poliage transparency, crown density, diabeck, and crown diameter [26]. The values of tree crown condition can be found in Table 3.

TABLE III
VCR VALUE IN CLUSTER PLOTS AT RAWA KIDANG RESTORATION

Cluster Plots	VCR
1	2.10
2	2.00
3	2.10
4	1.90

Note : VCR: Visual Crown Ratio

After obtaining the crown condition value, determine the score value. The header condition parameters are shown in (Table 4).

TABLE IV
THE HEADER CONDITION

Score Value	Value Range
1	1.90-1.92
2	1.93-1.95
3	1.96-1.98
4	1.99-2.01
5	2.02-2.04
6	2.05-2.07
7	2.08-2.10
8	2.11-2.13
9	2.14-2.16
10	2.17-2.19

2) Tree Health Value Result: The final tree health score is derived by combining each tree health parameter's weight and score values. The score value is taken from each tree health parameter, namely from the highest and lowest values. Tree health values are served in Table 5.

TABLE V
HEALTH VALUE OF TREES IN RAWA KIDANG RESTORATION

Cluster Plot	CLI			VCR			NKP	Category
	NS	NT	Results	NS	NT	Results		
1	3	0.27	0.81	7	0.22	1.54	2.35	Low
2	6	0.27	1.62	4	0.22	0.88	2.50	Low
3	8	0.27	2.16	7	0.22	1.54	3.70	High
4	10	0.27	2.70	1	0.22	0.22	2.92	Medium
Mean							2.87	Medium

Note: NS: Score value; NT: Weighted value; NKP: Tree health value

B. Discussion

Information regarding the importance of knowing tree damage needs to be carried out to rejuvenate trees affected by disease in the future. Figure 3 shows the location of the most damage to tree parts at the research location, including leaves (9) with 40 cases, branches (7) with 21 cases, the lower trunk (3) with 14 cases, and shoots and buds (8) as many as 15 cases. Leaves and stems are the parts of the tree that are most easily attacked by disease. Leaves are part of the crown of a tree; therefore, leaf damage can affect the condition of the crown [27].

WKNP is a nature conservation forest area that is part of a natural reserve area [28] The main component of a forest is trees. Tree health can be described by the ability of the tree to perform its physiological functions properly or not [29]. Damaged trees can hinder the tree's physiological function from running optimally, thereby impacting forest productivity [12]. The height of a place can influence tree damage. The higher the place, the lower the spread of the disease [17].

Figure 4 describes the most damage experienced at the research location, namely open wounds (03) in 13 cases, loss of dominant shoots (21) in 13 cases, branches broken or dead (22) in 20 cases, and damaged leaves, shoots, or buds in 38 cases (24). Leaves are part of the crown and have an essential function in trees. One of the functions of leaves is to be a place for the photosynthesis process, which influences tree growth [18]. Therefore, if the leaves are damaged extensively, it will disrupt the tree's photosynthesis and growth processes. This can reduce the availability of sufficient food, which can also impact rhinos' growth [30]. In addition to leaf damage, open wounds can contribute to a decline in tree condition by allowing the introduction of microorganisms such as mold, bacteria, or viruses into the stem [6]. Each tree exhibits varying levels of

sensitivity to damage, resulting in differences in the type and severity of damage experience [23].

After assessing the location of damage, type of damage, and severity, the cluster plot level damage calculation results can be seen Table 1. From Table 1, it can be seen that the highest value is located in plot cluster 1 at 3.17 and the least in plot cluster 4 at 1.42. The high value indicates that the plot cluster is highly damaged, while the lowest value indicates that the plot cluster experienced low damage [18]. Both biotic and abiotic factors influence the level of tree damage. Damage attributed to biotic and abiotic factors manifests as abnormalities in tree organs and the presence of pest organisms, identifiable through symptoms such as changes in texture, color, and size. The damage observed at the research location was attributed to various factors, including pests, environmental conditions, human activities, and disease attacks.

The cause of the breakdown of trees is identifiable and evaluated so that preventive measures can be taken before more significant damage occurs. Damage caused by pests and diseases can be handled by providing insecticides and fungicides so that pest and disease populations can be reduced [19], Table 3 is the result of measuring the condition of the tree canopy.

Table 3 shows that [21] plot cluster 1 got the highest score, namely 2.10, and plot cluster 4 got the lowest score, 1.90. The high and low VCR values can describe the conditions of photosynthesis in the tree. Damaged crowns will prevent the nutrients needed during photosynthesis, only a small amount of which will be transported to the leaves. Meanwhile, a high VCR value suggests that the photosynthesis process in leaves is going well, so it also has a good impact on the growth of tree leaves. Leaves are significant because rhinos use leaves

as the part often used as food compared to other parts of trees. Several factors can influence canopy conditions, namely the surrounding environment, such as water, growing space, sunlight, and the availability of nutrients [31].

The cause of the difference in VCR values is maintenance by managers, such as applying fertilizer to plants. Fertilization can increase canopy growth by growing new leaves that make up the crown. Fertilizing can also contribute to enhancing the (CEC) value of the soil, thereby promoting the development and growth of trees [32]. After getting the CLI and VCR values, the final tree health value can be determined. Table 5 shows that the highest tree health is the value possessed by plot cluster 3 at 3.16, and the lowest value belongs to cluster plot 1 at 1.81, with an average final tree health value at the Rawa Kidang Restoration of 2.23 in the medium category. This is because tree damage occurs a lot in plot cluster 1. The higher the final tree health value, the better the condition of the existing trees will be. However, the lower the tree's health value, the worse the condition of the tree [19], Plant growth is greatly influenced by the intensity of sunlight [27].

The tree leaves dominate the damage that occurs, so this also affects the condition of the tree crown. As is known, the main constituent of a tree crown is the leaves. Poor tree health conditions are due to the small value of crown conditions and the significant value of tree damage. Severe tree damage is caused by many pests and diseases on the trees, as well as environmental factors that occur [33].

IV. CONCLUSION

Forest health has been defined as producing forest conditions that directly satisfy human needs and by resilience, recurrence, persistence, and biophysical processes that lead to sustainable ecological conditions. Our definitions and understanding of forest health are also dependent on spatial scale. The average tree health value in the four plot clusters is in the medium category. The severity of canopy/crown conditions and tree damage can be influenced by surrounding environmental conditions such as sunshine, growing conditions, water, and growing space.

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