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TREES HEALTH ASSESSMENT IN BOGOR BOTANICAL GARDEN, WEST JAVA

Pendugaan Kesehatan Pohon di Kebun Raya Bogor, Jawa Barat

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ABSTRACT

Bogor Botanical Garden (BBG) is an ex-situ plant conservation area intended for conservation, research, education, tourism, and environmental services. As a tourist destination, BBG attracts many people every day. Human activities and unfavourable environmental conditions have caused damage to the existing collection. In 2021, 2022, and 2023, tree health monitoring was carried out using the Forest Health Monitoring method and repeated in 2024 by this research to assist the BBG management in ensuring the tree collections remain healthy and sustainable and provide a safe and comfortable environment for visitors. Seven clusters based on tree family dominance have been made for tree health monitoring. The monitoring includes the location, type, and severity of damage to individual trees in clusters 2, 3, 5, and 6. Some new damage types are found in the clusters. However, Damage Index values (DIV) in 2024 at clusters 2, 3, and 6 are categorized as healthy and DIV cluster 5 has changed to the light damage category. We observed that damages that have occurred are interdependent, where one damage can cause another damage. These findings suggest the importance of the BBG managers to provide immediate action on damaged trees to maintain the collections.

Keywords: damage; forest; health; monitoring; trees.

ABSTRAK

Kebun Raya Bogor (KRB) merupakan kawasan konservasi tumbuhan ex-situ yang ditujukan untuk konservasi, penelitian, pendidikan, wisata, dan jasa lingkungan. Sebagai tujuan wisata, KRB menarik banyak orang setiap harinya. Aktivitas manusia dan kondisi lingkungan yang kurang mendukung menyebabkan kerusakan pada koleksi. Pada tahun 2021, 2022, dan 2023 dilakukan pemantauan kesehatan pohon dengan metode *Forest Health Monitoring* dan diulangi pada tahun 2024 dengan penelitian ini untuk membantu manajemen KRB dalam memastikan koleksi pohon tetap sehat dan lestari serta menyediakan lingkungan yang aman dan nyaman bagi pengunjung. Tujuh kluster berdasarkan dominasi famili pohon telah dibuat untuk pemantauan kesehatan pohon. Pemantauan meliputi lokasi, jenis, dan tingkat keparahan kerusakan pada masing-masing pohon di kluster 2, 3, 5, dan 6. Beberapa jenis kerusakan baru ditemukan. Namun, Nilai Indeks Kerusakan (NIK) pada tahun 2024 di kluster 2, 3, dan 6 masih dikategorikan sehat dan NIK kluster 5 berubah menjadi kategori kerusakan ringan. Kerusakan yang terjadi saling bergantung, dimana satu kerusakan dapat menyebabkan kerusakan lainnya. Hal ini menunjukkan pentingnya pengelola KRB untuk segera melakukan tindakan terhadap pohon-pohon yang mengalami kerusakan untuk mempertahankan koleksi.

Kata kunci: hutan; kesehatan; kerusakan; pemantauan; pohon.

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A. INTRODUCTION

Botanical garden is an ex-situ plant conservation area designated for conservation, research, education, tourism, and environmental services (Indonesia's Presidential Regulation No. 83/2023). The oldest botanical gardens in Southeast Asia, established in 1817, is the Bogor Botanical Garden (BBG), located in the heart of Bogor City, West Java (Rachmadiyanto 2024). Located in a strategic location, makes BBG a popular tourist destination for both local and international visitors. According to Miardini (2006), several factors can disrupt plants, including animals, humans, natural disasters, weather, and the environmental conditions where trees live. The highly dynamic human activities within the BBG area can further contribute to the damage of its collections. Over the past two decades, the number of plant collections in botanical gardens has declined by 26.74%, from 4,300 specimens in 1980 to 3,150 in 2018 (Affandi *et al.* 2020). The latest registration data from the Bogor Botanical Garden (2023) indicates a total of 11,641 living specimens, 5,084 of which are tree species.

Forest Health Monitoring (FHM) method was introduced by the United States Department of Agriculture (USDA) in 1993 to monitor forest health. Indonesia was the first country to apply this method outside the subtropical region. Given the significant differences between tropical and subtropical forests, adjustments were made to implement the FHM method in Indonesia (Pratiwi & Safe'i, 2018). FHM includes four main indicators for monitoring tropical forests in Indonesia, e.g.: production, biodiversity, vitality and health, and site quality (Supriyanto & Iskandar 2019). Previous tree health monitoring using the FHM method was conducted in Bogor Botanical Garden in 2021 (cluster 2), 2022 (cluster 3), and 2023 (clusters 5 and 6). While cluster-level damage index values indicated healthy conditions, plot-level indices revealed light damage in some areas, with dominant tree damages including advanced decay, liana growth on trunks or canopies, broken or dead branches, dieback, open wounds, and stem cankers. According to Arwanda *et al.* (2021), most damage was observed on tree trunks with varying severity levels. Such damage can affect tree growth, reduce canopy vitality, biomass, and ultimately lead to mortality.

As an ex-situ conservation area and a popular tourist destination, the Bogor Botanical Garden must maintain healthy and safe tree collections to support visitor activities. Therefore, this study aims to assess the health condition in the BBG using the FHM method and to investigate the causes and impacts of tree damage in the garden. The results of this research are expected to assist the BBG management in ensuring the tree collections remain healthy, sustainable, and provide a safe and comfortable environment for visitors.

B. METHODS

This research was conducted in clusters 2, 3, 5, and 6 of the Bogor Botanical Garden (BBG) (Figure 1), located at Jl. Ir. H. Juanda No. 13, Bogor City, West Java.

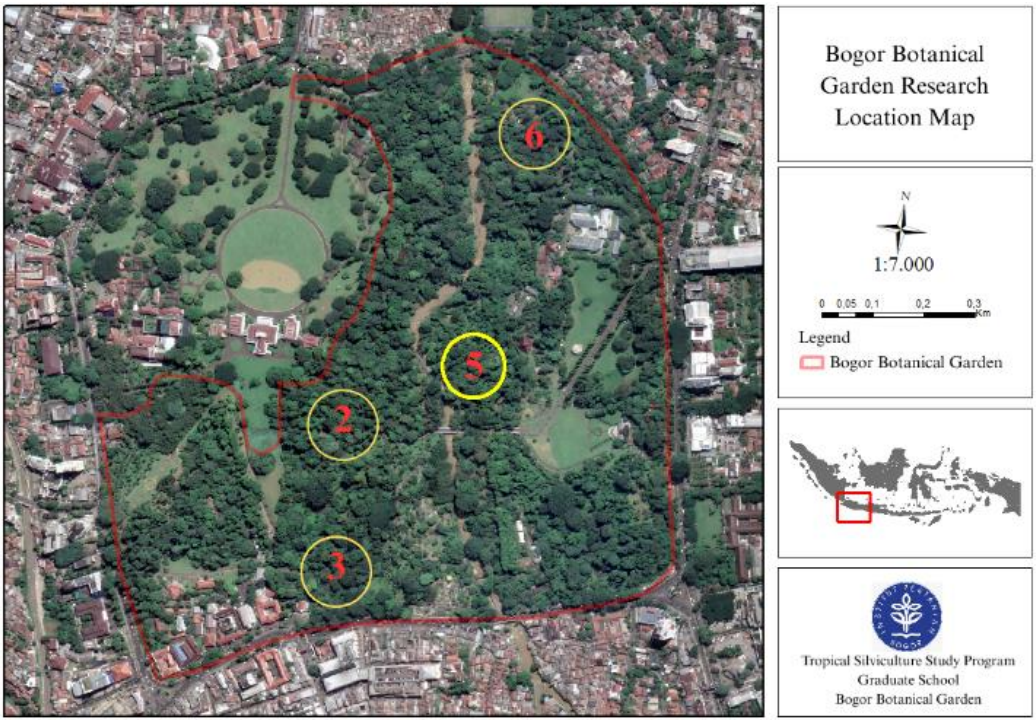

Figure 1. Bogor botanical garden map

Research Procedures

1. Plot Design and Data Collection

FHM cluster plots represent a 1-hectare forest area and consist of four annular plots and subplots (Figure 2). Trees in each plot were numbered clockwise based on azimuth, starting from the north. Annular plots collected data on poles and tree levels, while subplots focused solely on tree levels.

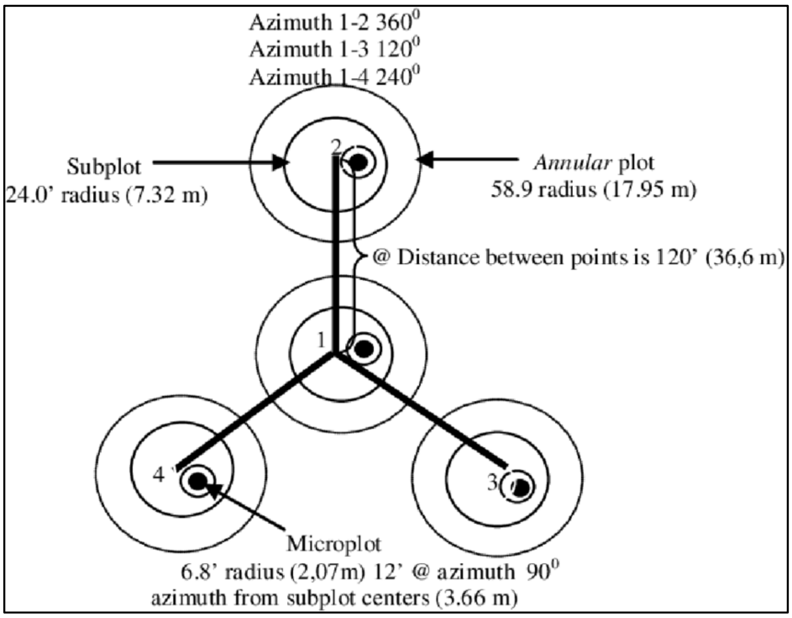

Figure 2. Cluster plot FHM design (Mangold, 1997)

The collected data included tree species, location, type, and severity of tree damage. All trees in the selected clusters were surveyed, and their damage conditions were recorded. Dead trees were excluded as they are not categorized as damaged trees. A maximum of three damage points per tree was recorded, starting from the lowest point. The damage location codes are outlined in Table 1 and Figure 3.

Table 1. Description of damage location codes

Code	Description
0	No damage
1	Exposed roots and "stump" (12 inches (30 cm) above ground level)
2	Damage to roots and the area between the roots and the lower trunk
3	Damage to the lower trunk (below the midpoint between the "stump" and the base of the canopy)
4	Damage to the lower trunk that also affects the upper trunk
5	Damage to the upper trunk (above the midpoint between the "stump" and the base of the canopy)
6	Damage to primary branches located in the canopy, above the canopy base
7	Damage to twigs (small branches and other branches except for primary branches)
8	Damage to young leaves and leaf tips
9	Damage to the canopy

Source: (Mangold, 1997)

The types of damage were identified based on the codes in Table 2, as observed on the trees. The damage types were recorded if they met the severity threshold. Once the location and type of damage were determined, the severity class of the damage was also recorded. For damages that did not meet the threshold, a value of '0' was assigned to their severity level (Table 3).

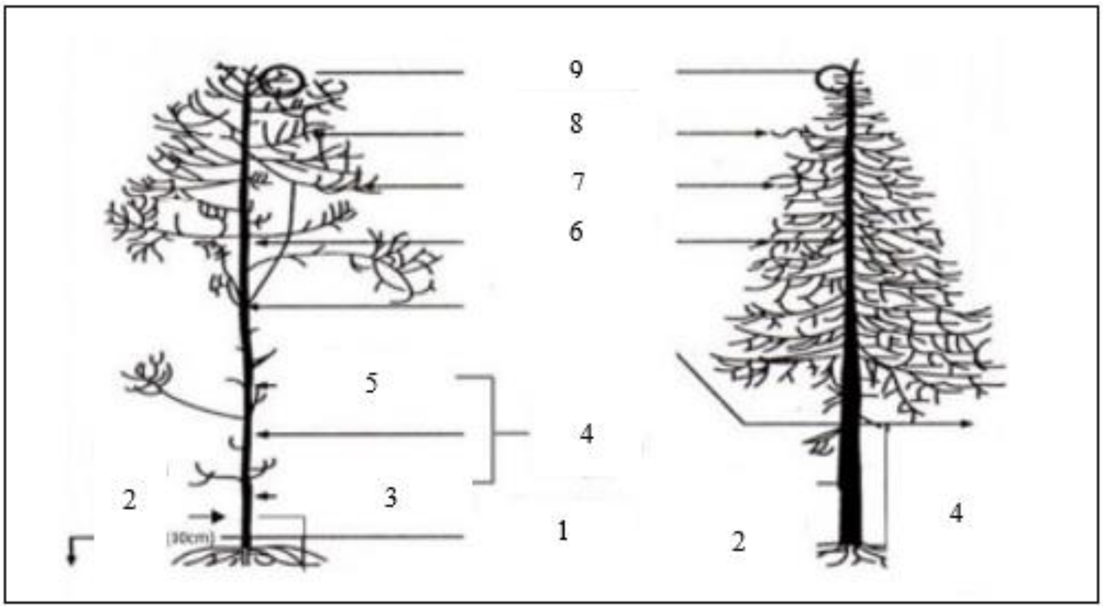

Figure 3. Location code of tree part damage indicator in FHM method (Mangold, 1997)

Table 2. Description of damage type codes and severity threshold values

Code	Definition	Severity Threshold (for 10% - 99% class)
1	Cancer, gol (purulent growth)	≥ 20% from the observation point
2	Conk, fruiting body, and other indicators of advanced decay	None, unless ≥ 20% on roots > 3 feet (0.91 m) from the trunk
3	Open Wound	≥ 20% from the observation point
4	Resinosis/gummosis	≥ 20% from the observation point
5	Cracked, broken, and peeling bark	None
6	Termite nests	≥ 20% from the observation point
7	Liana on trunk	≥ 20% from the observation point
11	Broken trunk or root less than 3 feet (0.91 m) from the trunk	None
12	Brooming on roots or trunk	None
13	Broken or dead roots > 3 feet (0.91 m) from the trunk	≥ 20% on the roots
20	Liana in the canopy	≥ 20% of the canopy affected
21	Loss of apical dominance, dieback	≥ 1% on branches in the canopy
22	Broken or dead branches	≥ 20% on twigs or tips
23	Excessive branching or brooming	≥ 20% on twigs or tips
24	Damaged leaves, buds, or shoots	≥ 30% of canopy leaf coverage
25	Leaves changing color (non-green)	≥ 30% of canopy leaf coverage
31	Other	-

Source: (Mangold, 1997)

Analysis of Tree Damage Index Value

After obtaining the damage codes, they are converted into damage values. The Damage Index Value (DIV) calculated using formula (1), damage for an individual tree calculated using formula (2), for a plot calculated using formula (3), and for a cluster can be calculated using formula (4).

DIV = Location Damage Code x Type of Damage Code x Severity Level Code (1)

TLI (Tree Level Index) = DIV 1 + DIV 2 + DIV 3 (2)

$$\text{PLI (Plot Level Index)} = \frac{\sum \text{TLI in the Plot}}{\sum \text{Trees in a Plot}} \quad (3)$$

$$\text{CLI (Cluster Level Index)} = \frac{\sum \text{PLI in the Plot}}{\sum \text{Plot}} \quad (4)$$

Tree, plot, and cluster-level damage indices were classified into tree damage classes as follows (Putra 2004):

Healthy : < 5
Light Damage : 5 – 9.99
Moderate Damage : 10 – 14.99
Severe Damage : ≥ 15

Table 3. Description of damage severity class codes

Code	Severity Class
0	01 – 09
1	10 – 19
2	20 – 29
3	30 – 39
4	40 – 49
5	50 – 59
6	60 – 69
7	70 – 79
8	80 – 89
9	90 - 99

Source: (Mangold, 1997)

Table 4. Weighting value for each location code, damage code, and severity level

Location code	Value	Damage code	Value	Severity code	Value
0	0	11	2.0	1	1.1
1, 2	2.0	1	1.9	2	1.2
3, 4	1.8	2, 6	1.7	3	1.3
5	1.6	12	1.6	4	1.4
6	1.2	3, 4, 5, 13	1.5	5	1.5
7, 8, 9	1.0	7, 20, 21	1.3	6	1.6
		22, 23, 24, 25, 31	1.0	7	1.7
				8	1.8
				9	1.9

Source: (Putra 2004)

C. RESULTS AND DISCUSSION

Tree Health in Bogor Botanical Garden

Factors causing tree damage can be divided into two categories: abiotic and biotic. Abiotic factors include all physical and chemical conditions in the environment surrounding the tree, such as natural disasters, temperature, and wind. Biotic factors consist of pests, diseases, or other living organisms that cause illnesses, such as fungi, bacteria, mycoplasma, viruses, parasitic plants, nematodes, and mammals (Abimanyu *et al.* 2019), Over time, tree damage at certain levels will affect tree growth and development within the forest, ultimately impacting forest health (Indriani *et al.* 2020). A healthy forest can be assessed based on the health of its constituent trees. A tree is considered healthy if it can carry out its physiological functions and exhibits high ecological resilience against pests and other factors. FHM , using the FHM method, assesses the overall health of an ecosystem as a critical component of sustainability. This method involves measuring four indicators as follows: (i) biodiversity, (ii) vitality (divided into canopy quality and tree damage), (iii) productivity, and (iv) site quality. In this study, the focus was solely on monitoring tree damage. The results of the type of tree damage can be seen in Table 5.

Table 5. Types of tree damage found in clusters 2, 3, 5, and 6 in different years

Code	Damage	Cluster							
		2		3		5		6	
		2021	2024	2022	2024	2023	2024	2023	2024
1	Cancer, gol (purulent growth)	√	√	√	√	√	√	√	√
2	Conk, fruiting body, and other indicators of advanced decay	√	√	√	√		√	√	√
3	Open Wound	√	√	√	√	√	√	√	√
4	Resinosis/gummosis				√				√
5	Cracked, broken, and peeling bark			√	√				√
6	Termiten nests		√	√	√			√	√
7	Liana on trunk	√	√	√	√	√	√	√	√
11	Broken trunk or root less than 3 feet (0.91 m) from the trunk	√	√	√	√		√	√	√
12	Brooming on roots or trunk						√		√
13	Broken roots	√				√			
20	Liana in the canopy		√	√	√	√	√	√	
21	Loss of apical dominance, dieback		√		√	√	√	√	√
22	Broken or dead branches	√	√	√	√	√	√	√	√
24	Damaged leaves, buds, or shoots	√						√	√
25	Leaves changing color			√		√			
31	Other	√	√			√	√		√

According to Ridwan (2021), eight types of tree damage were recorded in Cluster 2. New types of damage identified in 2024 include termite, liana growth on trunks and canopies, and loss of apical dominance and dieback. In cluster 2, the number of damage types increased compared to the 2021 monitoring. However, the Damage Index Value remained in the healthy category although it increased from 2.93 in 2021 to 4.185 in 2024.

The health monitoring conducted in Cluster 3 by Pamunca (2022) identified 10 types of damage. Resinosis/gummosis and loss of apical dominance and dieback were found in 2024. The resulting DIV was 4.35, while in 2024, it decreased to 3.193, remaining the cluster in the healthy category but showing a slight decrease.

In cluster 5, according to Nabawiah (2023), eight types of damage were identified in 2023. Conk, broken trunks and broomings on trunk were observed as new types of damage in 2024, resulted to the slight increase of the DIV from 4.548 (2023) to 5.671 (2024). Although the two values are only having slight differences, the DIV in 2024 fell into the light damage category, indicating an increase in both the types and severity of damage in cluster 5.

In cluster 6, 10 types of damage were identified in 2024, consistent with the findings in 2023, except that no cracked/peeled trunks, brooming on roots, or damaged buds/shoots were observed (Wahyuni 2023). The Damage Index differences were 2.61 (2024) and 2.62 (2023), which are nearly identical and still fall within the healthy category. The increaseor decrease in the number of damage types found, despite the unchanged, may be due to various factors, such as management efforts to address previous damage, which simultaneously resulted in the emergence of other types of damage.

Causes and Impacts of Tree Damage

Tree damage can be visually identified and occurs due to various factors. According to Waruwu *et al.* (2022), the factors causing tree damage can be categorized into two types: physical and biological. Physical factors include wind, water, drought, lightning, volcanic activity, and others. Biological factors refer to the effects of living organisms, including humans, animals, and plants (weeds). According to Fitriandhini & Putra (2022), forests serve important functions, including water retention, acting as a giant umbrella, being the lungs of the earth, and providing a habitat for primary needs. Tree damage can result in a variety of negative impacts, directly affecting the overall health and function of the forest. Forest disturbances can result in a range of consequences, such as the loss of various plant and animal species, disruption of the water cycle, floods, soil erosion, and droughts. As a tourist destination, BBG may face operational challenges as a result of tree damage. Damaged trees are at risk of falling, potentially endangering visitors. The results of the tree damage category observations in BBG are presented in Table 6.

Table 6. Damage categories and tree damage index values found in clusters 2, 3, 5, and 6

Cluster Observation	Damage Category				Cluster Level Index (CLI)
	Healthy	Light damage	Moderate damage	Severe damage	
Cluster 2	31	10	3	0	4.185
Cluster 3	31	9	1	1	3.193
Cluster 5	28	24	3	1	5.671
Cluster 6	42	12	2	0	2.610
Total	**132**	**55**	**9**	**2**	

Table 6 presents the categories of tree damage observed in clusters 2, 3, 5, and 6. Cluster 5 exhibits the lowest number of healthy trees, likely due to its designation as an area for liana collection. Liana, which is a form of damage present in FHM, contributes to the higher incidence of trees categorized as lightly damaged. In contrast, Cluster 6 contains the greatest number of healthy trees, which can be attributed to the cluster's infrequent visitation by visitors.

Table 7 presents the various types of damage observed across all monitored clusters. The most prevalent form of damage is liana growth on the trunks, while damaged buds or shoots are the least frequently encountered. In Cluster 5, nearly all trees serve as hosts for liana growth. A total of 73 cases of liana growth on trunks and 36 cases on the canopy were recorded across all clusters. Cluster 5 revealed lianas whose growth has surpassed the threshold, as illustrated in Figure 4. These lianas have encased the trunks and canopies of the trees they inhabit, extending from one canopy to another. This extensive growth may also disrupt humidity levels by limiting light penetration. Lianas are plants whose roots are anchored in the soil, but whose stems and leaves extend onto host plants in order to capture sunlight. One such liana species found in the BBG collection is *Philodendro*n sp., which, according to Insany *et al*. (2024), has an estimated 14,755,405 plants, making it the largest cultivation center in Indonesia, particularly in the West Java region.

Figure 4. Types of liana damage also collected in cluster 5, covering the trunk up to the tree canopy

Table 7. Number of damage types found in clusters 2, 3, 5, and 6

Code	Damage	Cluster				Total
		Cluster 2	**Cluster 3**	**Cluster 5**	**Cluster 6**	
1	Cancer, gol (purulent growth)	1	1	2	3	7
2	Conk, fruiting body (fruit body), and other indicators of advanced decay	5	4	3	4	16
3	Open wound	3	5	1	4	13
4	Resinosis/gummosis		1		2	3
5	Cracked, broken, and peeling bark		6		4	10
6	Temite nests	3	2		7	12
7	Liana on trunk	16	6	43	8	73
11	Broken trunk or root less than 3 feet (0.91 m) from the trunk	2	3	1	2	8
12	Brooming on roots or trunk			1	1	2
20	Liana in the canopy	3	8	25		36
21	Loss of dominant tip, dieback	4	9	8	2	23
22	Broken or dead branches	1	11	4	22	38
24	Damaged leaves, buds, or shoots				1	1
31	Other	5		1	4	10
	Total	**43**	**56**	**89**	**64**	**252**

As shown in Figure 5, the liana growth has covered the entire surface of the trunk, resulting in open wounds. As noted by Simamora *et al*. (2015), another detrimental effect of liana growth is the formation of open wounds on the trunk. A total of 13 cases of such open wounds were identified. Open wounds refer to one or a series of injuries that cause the bark to peel away, which can occur due to natural tree activity or external intervention by living organisms. If left untreated and exceeding the threshold, open wounds can provide an entry point for various pathogens, which can ultimately harm the tree's health (Indriani *et al.* 2020).

Figure 5. Types of open wound damage caused by liana on the trunk

Open wounds caused by lianas or other factors can become infected by pathogens, which may lead to cancerous growths. In a study conducted by Erwin *et al*. (2002), rubber trees attacked by fungal pathogens showed indications of cancerous damage. The fungal hyphae penetrate the wood cells through the wounds on the trunk. A total of 7 cases of cancerous damage were identified, one of which is shown in Figure 6. Cancer refers to the death of the bark tissue, while the living tissue surrounding the cancerous area thickens as part of the tree's defense mechanism, known as callus formation. Callus is a thick tissue that prevents pathogens from penetrating. Cancer can cause the trunk to lose its cylindrical shape, and at specific heights, particularly in the areas affected by cancer, the tree's diameter increases due to the callus formation.

Figure 6. Types of cancer damage on the tree trunk in cluster 6

Another form of damage observed is conk and advanced decay indicators, with a total of 16 cases identified across all clusters. According to Herliyana (2012), pathogens can spread in several ways: air-borne, where spores are carried by the wind and attach to open wounds on trees; mechanical wounds, which reduce the tree's resistance to pests and diseases; root contact, as large trees with extensive roots may come into contact with the roots of other trees; and soil-borne, where pathogens spread through the soil in the form of mycelium, spores, fruit bodies, or plant tissue remnants from diseased plants. Conk is a disease characterized by the presence of fungal fruit bodies growing on parts of the tree. Conk growth on tree sections such as the trunk or roots can cause the tree to become more prone to falling, as the trunk or roots undergo advanced decay. There are two stages of decay caused by fungi: the early stage and the advanced stage. In the early stage, discoloration and hardening of the tree's surface are observed, followed by structural changes in the tree. In the advanced stage, the tree's strength decreases, making it more susceptible to rot and eventual collapse (Prabawati 2017). The types of conk damage and advanced decay are shown in Figure 7.

Figure 7. Types of damage observed: a. cancer in cluster 3, and b. decay in cluster 5

Exudation can be divided into two types: resinosis and gummosis, which refer to the release of fluids at sites of damage. This type of damage was observed in three cases. Resinosis is characterized by the discharge of clear or brown fluid caused by pests or pathogens, while gummosis refers to the release of gum or polysaccharide gel from infected areas. This condition occurs due to the rupture of wood tissue caused by advanced damage from pathogenic fungal infections attacking open wounds on trees. This is often followed by pest infestations and physiological changes in the plant (Fikri *et al*. 2023). An example of exudation can be seen in Figure 8.

Figure 8. Type of exudation damage in cluster 3

Damage to trunks, branches, and roots was observed in 56 cases across all clusters. The recorded damage included broken, cracked, or peeled trunks; trunks or roots fractured within 3 feet (0.91 m) from the base; broken or dead branches; and fractured roots. Trunk damage is attributed to various factors, including decay, lightning strikes, and anthropogenic activities, and is categorized as severe damage (Arisanti *et al*. (2022); Suwarna *et al*. (2014). Damage to branches, such as breakage or mortality, is often caused by pest and disease infestations or competition among trees due to high stand density (Safe'i *et al*. 2020). Such damage can result in reduced canopy cover, diminished growth rates, biomass loss, and, in extreme cases, tree mortality (Nuhamara *et al.* 2001). Similarly, root damage significantly disrupts photosynthetic processes, as roots are vital for water uptake and the absorption of essential nutrients necessary for tree survival and growth (Fikri *et al.* 2023). Examples of trunk, branch, and root damage are illustrated in Figure 9.

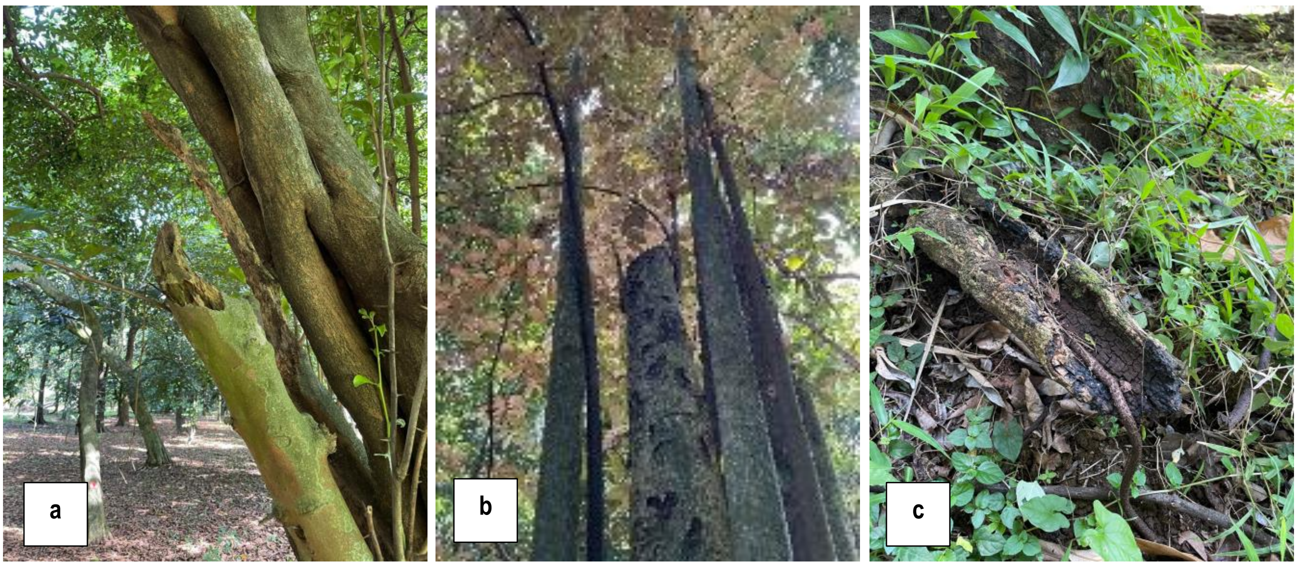

Figure 9. Types of damage observed: a. Broken branch in cluster 6, b. Broken trunk in cluster 2, c. Broken root in cluster 6

Termite nests, observed in 12 cases, is attributed to environmental conditions that are highly favorable for termite nesting and activity (Figure 10). The prevalence of termite nests is likely due to their rapid rate of spread, as noted by (Arwanda *et al.* 2021). These nests were predominantly located on tree trunks, which aligns with findings by Robinda (2023), who reported that cellulose—a primary component of wood and a key food source for termites—constitutes approximately 42–47% of the structural composition of wood. Termites thrive under specific environmental conditions, requiring relative humidity levels between 75–90% and temperatures ranging from 15°C to 38°C. The environmental conditions within the Bogor Botanical Garden (BBG) closely match these preferences, providing an optimal habitat for termites. Extensive termite activity can cause internal hollowing of tree trunks, compromising structural integrity and potentially resulting in tree mortality (Arwanda *et al.* 2021).

Figure 10. Type of termite nest damage in cluster 6

Brooming damage was observed in 2 cases, one of which is illustrated in Figure 11. Brooming refers to the abnormal growth of shoots that proliferate excessively, which may occur on roots, trunks, or branches. This type of damage affects the tree's reproductive processes by disrupting the efficient distribution of metabolic products within the tree (Fikri *et al.* 2023). Excessive growth can result from genetic abnormalities inherited from the parent tree or environmental factors.

Figure 11. Types of broom damage in cluster 6

Loss of dominant tips (Figure 12) and dieback was recorded in 23 cases. The consequences of this damage include the death of the tree's shoot, color changes, and the development of bald spots on the shoot tips. Such damage may result from plant tissue damage, blockage of xylem tissues, absorption of toxic salts, bacterial infections, low temperatures, drought, and pest infestations (Rikto 2010). Other types of leaf damage observed included damaged buds or shoots, recorded in 1 case. Rikto (2010), notes that leaf damage, such as spots or lesions, indicates tissue death. Leaf spots may eventually progress to holes in the leaves, potentially caused by pathogenic fungi.

Figure 12. Types of damage to the loss of the dominant tip in cluster 6

Code 31 refers to other types of damage, specifically those not included in the damage classification within the FHM methodology. A total of 10 cases were identified across the four clusters, encompassing issues such as epiphytes (Figure 13a), ant nests (Figure 13b), and broken branches due to pruning. The epiphytes observed on the host trees were of considerable size, which could result in branch breakage due to the excessive weight. Although epiphytes do not directly harm trees, Stanton *et al.* (2014) state that during transpiration, epiphytes release vapor while photosynthesizing, which subsequently leads to microclimatic changes beneath the canopy. The presence of ant nests, similarly to termite nests, can also cause damage. According to Emil (2021), ants require specific abiotic factors, such as air humidity, temperature, and light intensity, to establish an ideal nesting environment. A suitable habitat will attract ants to settle. For instance, the rangrang ants require an environment with temperatures ranging from 26-34°C and relative humidity levels between 62-92%.

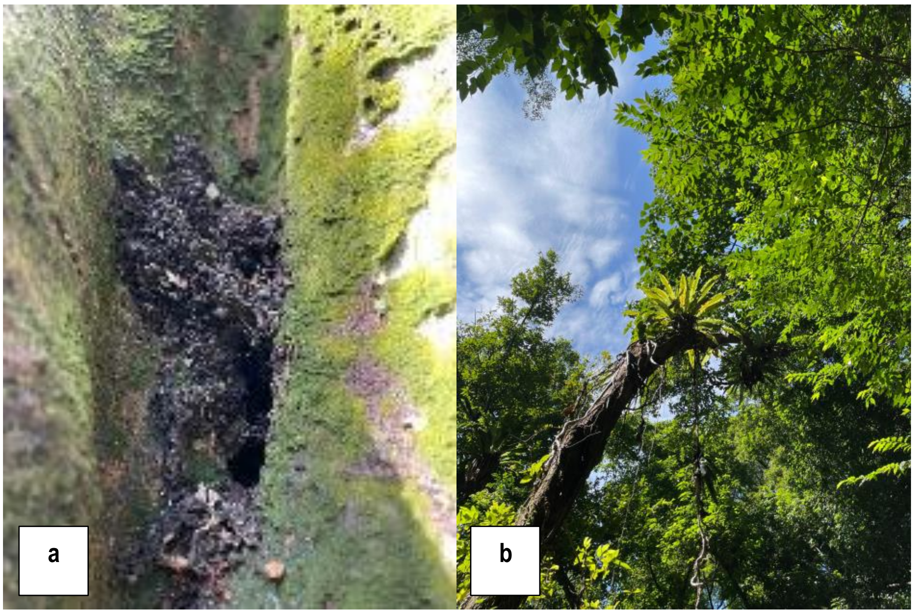

Figure 13. Other types of damage a. Ant nests in cluster 6, b. Epiphytes in cluster 2

The impact of damage to trees leads to a decline in physiological functions, subsequently reducing the tree's growth rate and potentially resulting in its mortality (Safe'i *et al.* 2020). The consequences of tree damage extend beyond the individual tree, affecting the surrounding environment. In the BBG, the various forms of damage are interrelated, with one type of damage often resulting from or leading to another. This interdependence underscores the critical need for managers to implement effective maintenance practices for trees exhibiting signs of damage, in order to interrupt or mitigate the cascading effects of damage and prevent further ecological consequences.

The increase in new types of damage found is caused by various things, such as actions taken by the management in dealing with damage that occurred previously, but at the same time other different damage appears. This can happen if the action taken by the management is not done thoroughly, so other damage that has not been handled can cause other damage to appear.

D. CONCLUSION

1. Tree health monitoring indicate changes in the types of damage observed between previous assessments and those conducted in 2024. Cancer, open wounds, lianas on stems, and broken or dead branches are types of damage that have consistently been present every year and across all clusters. Clusters 2, 3, and 6 are categorized under the healthy index value, while Cluster 5 falls under the light damage category.
2. The damage types are interrelated. Lianas can cause open wounds, which may then lead to cancer, decay, rot, and exudation. Additional damage observed includes broken stems, branches, and roots; termite nests; broom; loss of the dominant tip; and other forms of damage such as ant nests and epiphytes.

AUTHOR'S DECLARATION

- Conflicts of Interest: None.
- We here by confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for republication,which is attached to the manuscript.
- No animal studies are present in the manuscript.
- No human studies are present in the manuscript.
- No potentially identified images or data are present in the manuscript.

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