Level of damage on *sengon* stand based on tree vitality indicators at *sengon* community forest in Serang District, Banten Province

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Abstract. *Sengon* plantation is the primary commodity of the community forests, which produces timber with high economic value, especially in Java Island. However, now the condition of sengon stands in Java Island, pests and diseases have attacked most. The information about the health and the severity of the stands due to pests and diseases is beneficial for determining stand productivity and investment security. The purpose of this activity is to determine the level of damage on sengon stands at various locations in Serang Regency, Banten, based on indicators of tree vitality. The method used to determine stand health is Forest Health Monitoring (FHM), which includes using tree vitality indicators and site quality indicators as a basis for assessment. The observation plot was carried out at 3 locations determined purposively based on the flat distance from the beach, which is ≤ 2 km; 2> X≤ 4 km; 4> X ≤6 km. The results showed that the average percentage of healthy sengon trees was still quite high (82.7%), but the level of damage to stands was moderate. The most common type of damage is gummosis (distance ≤ 2 km and > 4-6 km) and boktor (> 2- 4 km). Many tree damage occurs in the main branch location found in the live canopy section (code 6), especially in plots that are 2> X≤ 4 km from the coastline and lower stem (distance ≤ 2 km). However, no damage was found at the root location (code 1), shoots (code 8) and leaves (code 9). The damage of the stem causes a decrease in wood production because the damaged at part of the stem cannot be used anymore. Visual Crown Ratio of sengon trees tends to be low due to young trees so that the canopy is not maximal. Maintenance activities, as well as mixed planting techniques with intercropping plants and other woody plants, can prevent sengon plants from attacking pests and diseases.

1. Introduction

*Sengon* (*Falcatoria moluccana* (Miq.) Barneby & J.W. Grimes) is one of the favorite species in the community forest, especially in Java Island. This caused by its high economic value compared with other species from the community forest. High market demand on sengon that increased every year resulted in its dominations in Java's community forest. This proved by its high sengon timber production, 97.16% from all sengon timber production [1].

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appeared on the stand that used a monoculture planting system. Susceptibility to pests and diseases were also influenced by narrow genetic variation (genetic base) [3].

Currently, the condition of sengon stands in Java Island has been attacked by various types of pests and diseases, such as caterpillar pest (*Xystrocera festiva*), gall rust (*Uromycladium tepperianum*) and redroot disease caused by fungus *Ganoderma pseudoferrum*. Pest and disease attacks on sengon stands influenced the age of the plant, the soil, silviculture techniques, mixing plant species, and slope of land [4]. Generally, sengon stands that attacked have a varied level of damage; the percentage of gall rust attack depends on its location from the coastline. The further away from its coastline, the higher tendencies on the attack, but this still needs further verification [5].

The information on forest health status, especially the level of damage caused by pests and diseases, was needed to support the productivity of sengon stands and ensure its investment. Effects on tree damages were tree growth decrease, low canopy condition, biomass loss, death and health of overall forest [6]. Therefore the information on tree damage is critical as an early warning, which will provide information about resiliency, sustainability, productivity, and sustainability of the forest. Forest Health Monitoring (FHM) was a method that could be used to determine to stand health and damage levels from pests and diseases because it used several ecological indicators that were measurable and influence each other. Tree vitality indicators conducted one of FHM methods. Vitality can be explained by the condition of tree damage and canopy condition because both of them greatly influence tree growth, which in turn will affect the quantity and quality of processed wood produced [7]. The tree vitality describes the fertility level of a species in its development as a response to the environment [8]. The goal of this research was to determine of sengon stands health in various distances from the coastline based on tree vitality indicators on Serang District, Banten.

2. Methodology
2.1. Time and location
The study was conducted in September 2016, at Umbul Tanjung Village, Cinangka District, Serang Regency, Banten Province (Figure 1). The observation plot was determined purposively based on distance from the coastline ≤ 2 km; > 2-4 km; and > 4-6 km. Geographically, the location of the village is in a position as shown in Table 1.

![Figure 1](image_url)

*Figure 1.* The research location at Cinangka District, Serang Regency, Banten Province.
Table 1. The geographical location of the plot cluster.

| Cluster Plot (km) | Annual Plot | Distance from the coastline (km) | South latitude | East longitude |
|-------------------|-------------|---------------------------------|----------------|---------------|
| ≤2                | 1           | 1.76                            | 06°13’ 49.4”   | 105°50’ 48.0” |
|                   | 2           | 1.72                            | 06°13’ 55.6”   | 105°50’ 46.9” |
|                   | 3           | 1.72                            | 06°13’ 48.9”   | 105°50’ 49.7” |
|                   | 4           | 1.60                            | 06°13’ 58.0”   | 105°50’ 45.7” |
| >2-4              | 1           | 2.20                            | 06°14’ 06.6”   | 105°50’ 57.2” |
|                   | 2           | 2.93                            | 06°13’ 30.5”   | 105°51’ 29.6” |
|                   | 3           | 3.50                            | 06°14’ 11.4”   | 105°51’ 46.5” |
|                   | 4           | 2.95                            | 06°13’ 28.3”   | 105°51’ 30.0” |
| >4-6              | 1           | 4.56                            | 06°13’ 16.3”   | 105°52’ 23.7” |
|                   | 2           | 4.26                            | 06°13’ 19.1”   | 105°52’ 24.6” |
|                   | 3           | 4.25                            | 06°13’ 18.0”   | 105°52’ 22.9” |
|                   | 4           | 4.56                            | 06°13’ 17.6”   | 105°52’ 24.0” |

2.2. Material and instrument

The research material that used was the sengon plantation aged 1.5-4 years old that was inclusive in the refinancing program of the Forestry Development Financing Center. The equipment used was diameter and height measuring instrument, tally sheet, stationery and camera.

2.3. Research procedure

2.3.1. Sample plots. The sample plots (cluster plots) were made three pieces, which were determined purposively based on the flat distance from the coastline, namely ≤ 2 km (cluster plot 1); > 2- 4 km (cluster plot 2); and> 4-6 km (cluster plot 3). Circular plot clusters consisting of 4 annular plots with a radius of 17.95 m (Figure 2). Subplot 1 is the central point of the entire subplot. The midpoints of the sub-plots 2,3 and 4 are respectively in the direction of 360°; 120°; 240° from the midpoint of the plot 1. The flat distance of each midpoint is 36.6 m.

Figure 2. Cluster design of the FHM sample plot [9].
2.3.2. Tree damage.
The object of observation and measurement was sengon trees that were in the annular plot area. The parameter of the condition of tree damage was observed based on location, type and severity variables. The location of damage consists of damage to roots, stems, branches, canopy, leaves, buds and shoots (Figure 3). The data for each location of damage, damage type code, and severity that have been obtained were given a weighting value (scored) that [6]. Data from the three damage variables are then summarized into one damage index until the tree damage level index (TDLI) is obtained. Then the annular damage index was calculated, and finally, the damage index is set for the plot cluster level, which is the final value in the tree damage assessment.

![Code description of damage](image)

Figure 3. Code description of damage [9].

2.3.3. Canopy conditions.
The canopy condition parameters consist of live canopy ratio, crown diameter, crown density, crown transparency and dieback. The assessment of the five variables were [10]:
   a. Live canopy ratio: The ratio of the length of the leafy stems to the total length of the stem;
   b. Canopy density: the percentage of sunlight that is held up by the canopy, which cannot reach the surface of the ground;
   c. Dieback: the percentage of branch death begins at the end of the branch and towards the base of the live canopy;
   d. Transparency canopy: the percentage of sunlight that can pass through the canopy and reach the ground surface;
   e. Canopy diameter: the average of the length and width of the tree canopies.

The results of the assessment of crown condition variables were classified into three crown condition criteria were good, moderate and poor (Table 2). The canopy condition data were collected in the Visual Crown Ratio (VCR) rating with a range of values 1-4 (Table 3). Furthermore, the VCR value of the annular plot was calculated. Finally, the VCR value was set for the plot cluster level to be the final value in the canopy condition assessment.
Table 2. Crown condition criteria [11].

| Parameters               | Good (value=3) | Moderate (value=2) | Poor (value=1) |
|--------------------------|----------------|--------------------|---------------|
| Live crown ratio (%)     | ≥ 40.0         | 22.1-39.9          | 5.0-22.0      |
| Crown density (%)        | > 55           | 45-55              | < 45          |
| Crown transpareancy (%)  | < 35           | 35-75              | > 75          |
| Dieback (%)              | < 5            | 5-25               | > 25          |
| Crown diameter (m)       | ≥ 10.1         | 2.5-10             | ≤ 2.4         |

Table 3. Criteria of visual crown ratio (VCR) [12].

| Value of VCR | Criteria                                                                 |
|--------------|---------------------------------------------------------------------------|
| 4 (High)     | The value of all canopy condition parameters are 3 or only 1 parameter has a value of 2, there is no parameter have value 1 |
| 3 (moderate) | More combinations of values 3 and 2 in the crown parameter or value of all parameters are 2, and there is no parameter have value 1 |
| 2 (low)      | At least 1 parameter has value 1, but not for all parameters              |
| 1 (very low) | All canopy condition parameters are value 1                               |

3. Results and Discussion

The tree damage assessment using Forest Health Monitoring (FHM) method includes three observation parameters, i.e., the type of damage, location, and severity. Results of the assessment showed that the types of sengon tree damage in Umbul Tanjung village, Cinangka District, Serang Regency were gall rust, gummosis, termite nests, boktor, and loss of apical dominant.

Gummosis is the most widely found type of damage at a distance of ≤ 2 km and > 4-6 km from the coastline (Figure 2a). Gummosis is a symptom of a disease, characterized by the discharge of a clear yellowish until blackish liquid on the part of a tree that is wound or rupture. The symptoms of this disease are formed as a tree reaction to pathogenic fungal attacks to localize pathogens so that they do not develop more broadly [13]. Gummosis was caused by Botryodiplodia theobromae and Phytophthora citrophthora [14, 15]. The gummosis coming out of the skin surface of the plant tissue indicates an advanced level of attack [13].

The dominant type of damage at a distance of > 2-4 km from the coastline was a boktor (Figure 4). The Boktor or Uter-Uter is a type of beetle from the stem borers Xystrocera festiva that, until now is still considered as the most detrimental pest to the sengon forest because it causes the stem to fracture, decreases the amount and quality of timber, and also caused the death [16].

Based on the stages of its life development, the boktor larva was the most damaging phase because it can attack the cambium and the outer part of sapwood [16] and caused the emergence of exfoliating holes (Figure 7). The drill holes cause the trunk to become damaged, dry, and vulnerable to broken or crushed by the wind. At the research site, some dead trees were almost primarily due to boktor attacks.

In this study, the existence of the Boktor pest was demonstrated by a large number of damages to the main branches, especially at distances > 2-4 km from the coastline (15 cases). Tree defects due to the presence of the hole will cause economic losses. Based on SNI 2001, round wood which has a hole in the entrance into the quality class two because the criteria for the first class of quality is not having a uterine hole (boktor). The drill holes in the sengon stem have decreased the selling value. In the case of Perhutani, the Sengon-round wood that has a boktor defect is classified into firewood (Rencek), thereby lowering the forest production of wood. Environmental conditions at a distance of > 2-4 km...
from the untreated coastline may be a trigger for the susceptibility of the sengon tree to the attack of pests, namely gall rust, gummosis, shoots, and boktor [16].

Figure 4. Frequency of damage based on the type of damage.

Figure 5. Frequency of damage based on the location of the damage.

Figure 6. Frequency of damage based on the level of damage.

Figure 7. Tree damage in the early stages of _uter-uter_ attacks.

Figure 8. the advanced stage due to _gempol_ attacks.
The environmental conditions at a distance of > 2-4 km were not maintained, that could be the possibility to trigger plants susceptibility of pests and diseases attack (gall rust, gummosis, broken shoots and boktor). Intensive maintenance was not carried out at these locations, such as land clearing and pest and disease control, so that the level of tree damage is very varied, and some even reach 75% of tree damage (Figure 5). The existence of shrubs that are quite tight makes microclimates with high air humidity, which encourages the growth of destructive fungi. Also, it creates competition for growth between sengon trees and weeds. Maintenance measures aim to overcome or prevent the development of the cause of the damage so that the tree can carry out its usual functions. Trees that have been damaged need to be prevented in the future. This effort is necessary to estimate the progress of damage that has existed until the period when the damage cannot be tolerated and requires the trees to be cut down.

The type of rust damage is relatively low (2 occurrences) and still under the threshold value of damage (still below 20%) as stipulated in the USDA FS. This condition is related to the history of sengon plantation in the Cianangka District, Serang Regency, which is the first rotation. Besides that, the planting pattern applied is planting a mixture with several other types of plants such as teak, pulai, African wood, melinjo, and jengkol. Nevertheless, the maintenance and monitoring of health conditions should still be noted, especially for Puru rust disease that is a cause of low productivity and health levels, in addition to Gummison and Boktorsk.

Based on the frequency of occurrence of damage, rootstock (distance ≤ 2 km and 4-6 km from the beach) and heading rod (distance 2-4 km from the beach) is the location or part of the tree that has been found most damage (Figure 4). Tree trunks are a part that provides the most significant economic benefit. Economically, damage to the trunk will cause losses, because the damaged stem can not be utilized anymore, so that wood production decreases.

There was no damage to the roots, branches, shoots & bud as well as leaves for all distances from the seashore found in this study. This condition strongly encourages the productivity of Sengon tree optimally, because if the condition of the leaves is damaged the photosynthesis process is disrupted, and other physiological processes such as transporting water and nutrients from the soil to the leaves are also disrupted. Sengon tree growth is also not obstructed because of the absence of interference in the process of water and mineral absorption from the roots to the whole plant tissue so that the photosynthesis process will run in a specific way.

Table 4. Tree damage index plot at the cluster level.

| Distance from the beach (km) | Percentage of healthy trees (%) | Tree damage index |
|-----------------------------|---------------------------------|-------------------|
| ≤ 2                         | 92.6                            | 3.01              |
| 2>X≤4                       | 86.6                            | 3.37              |
| 4>X≤6                       | 90.7                            | 2.97              |
| average                     | 90.0                            | 3.12              |

The health assessment of the tree that has been done against the three damage parameters is then summarized in a damage index that can show a tree's level of health. The damage of sengon at Umbul Tanjung Village, Cianangka District, was classified as moderate by the value of PLI (Plot damage index level) at 3:12 of 6.5 (Table 4) with a percentage of 88.5% of healthy trees.

Table 4 indicated that the damage index value for a distance of 2-4 km from the coastal side is relatively higher (3.37 than 6.5) compared to the other two locations. The results describe that the level of tree health at a distance of 2-4 km from the beach is the lowest. This is possible because of the environmental condition surrounding the trees, which is filled by shrubs and bushes (weeds), which are the host of intermediaries for disease-causing bacteria.
Nevertheless, the number of healthy trees tends to be relatively high (82.7%). It is expected that regular weeding can reduce the level of damage that it causes economic losses. Tree damage affects the growth of the tree so that it will affect the quantity and quality of wood that will be produced. The tree damage index to indicate the tree health level is also an illustration of the potential threat of damage in the future.

The other indicators used to assess the health of sengon stands was the condition of the tree canopy that can be known from the Visual crown Ratio (VCR). Inferior trees with small or not dense canopy can be caused by the influence of competition with other plants, less or excess of humidity or other influences such as disease on the foliage, insect defoliation, or wind Storm [17].

The assessments of VCR for each tree based on five variables of crown condition, i.e., the live crown ratio, crown diameter, crown density, crown transparency, and dieback. All of these variables are important indicators that can predict the future of crop survival—the VCR of the Sengon tree, as in table 5.

| Distance from the beach (km) | Live crown ratio (%) | Crown Diameter (m) | Crown density (%) | Crown transparency (%) | Dieback | Visual crown Ratio |
|-----------------------------|----------------------|--------------------|-------------------|------------------------|---------|--------------------|
| ≤ 2                         | 34.5                 | 5.2                | 35.8              | 64.8                   | 0.0     | 2.21               |
| 2>X≤4                       | 34.7                 | 5.5                | 30.7              | 69.3                   | 0.0     | 2.04               |
| 4>X≤6                       | 24.4                 | 5.9                | 28.7              | 71.3                   | 0.0     | 2.00               |
| average                     | 31.2                 | 5.5                | 31.7              | 68.5                   | 0.0     | 2.08               |

The assessment showed that the VCR Sengon tree tended to be the same at all distances from the seashore by the range of 2.00-2.21 or, on average, 2.08 of the scale of 1-4 [12]. Based on the classification of VCR (1 = very low, 2 = low, 3 = Medium, and 4 = high), then the VCR stands on all plot clusters, including low. The crown condition is low because of its small density of < 45%. The healthy tree is characterized by a crown density of > 50% [18].

In this study, a low-generated VCR value was affected by a low-crown density value of 31.7%. However, the low value of the crown density is likely because the plant is generally young (2-4 years old), hence the crown has not been developed entirely. However, it was also because the plant has been infected with pests and diseases, so the growth of the crown was disturbed. The impact of tree damage will result in declining growth rates, low crown conditions, biomass loss, and especially tree death; and will impact on the overall forest health [6]. Tree damage will be significant as an early warning and will provide information about the flexibility, sustainability, productivity, and sustainability of the forest.

4. Conclusion
The level of damage in forest stands sengon at the community forest of Umbul Tanjung Village, Cinangka District, Serang Regency, was moderate, but there are still many healthy trees. The highest damage type was gummosis at a distance ≤ 2 km and >4-6 km from coastline; and boktor at a distance> 2-4 km from the coastline. The most severe tree damage was the main branch at a distance> 2-4 km from coastline and the lower stem at a distance ≤ 2 km from the coastline. The damage of the sengon stand causes the timber production of sengon decline. Visual Crown Ratio of sengon trees tends to be low because the trees were young, so the canopy was not optimal.

Acknowledgments
The author would like to thank the Center for Forestry Development Financing (P3H) for financial support and cooperation so that this research can be carried out. The author also expresses the deepest gratitude to Dr. Agus Astho Pramono, MSi, at the suggestion and inputs. We thank Mr. Dwi Haryadi, S.Hut, the technicians of the Center of Research and Development Forestry Tree Seed Technology,
Mrs. Epa Wijaya Ningsih, S.E, and Ir. Katrina Ginting from P3H for helping to collect the data in the field.

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