Landscape Characteristics on Forest Health Measurement Plots in Several Forest Functions

P S Anwar, R Safe’i, and A Darmawan
Department of Forestry Faculty of Agriculture University of Lampung
E-mail: rahmat.safei@fp.unila.ac.id

Abstract. The assessment of tree damage aims to measure the level of tree damage so that the tree damage assessment can measure the level of disturbance to trees so that they can know the condition of the forest and know what happens in the future. This study aims to determine the landscape characteristics in the cluster of health measurement plots in three forest functions (production forest, conservation forest, and protection forest). The stand damage index for the cluster plots was collected, and perform spatial analysis, which included stand damage in the cluster plots based on landscape characteristics (road distance, slope, and elevation). The tendency of damage due to reach from the road tends to damage other stands. Significant damage occurred in conservation forest rather than protection forest and production forest with a percentage value of 98%. Slopes have a reasonably substantial damage effect-the higher the hill, the more damage to the stand. The gradient of 25-40% (steep) has a significant impact on protected forests with a percentage of 85%. Altitude does not matter much where low height causes considerable damage-substantial damage to production forests <500 masl.

1. Introduction
Forest management relates to the utilization of forests as natural resources in an ecosystem, so it is necessary to pay attention to every aspect of utilization, supervision, and protection. The state forest area divides forest functions into production forest (including community forest), protection forest (including community forest), and conservation forest. Current and future forest management require information regarding the health condition of the forest for its development [1]. Monitoring forest health conditions are concerned with monitoring damage that kills trees or affects tree growth in the long term.

Currently, modern forest health management seeks to control damage to remaining below an acceptable economic threshold [2,3]. The intensity of control is needed if the damage is above the economic threshold. The amount of costs incurred depends on the management objectives and the amount of loss incurred [4]. It is necessary to detect tree damage early as possible to allow for unhealthy tree treatment measures and minimize tree damage [5]. Detection can avoid accidents caused by fallen trees [6]. Trees are said to be healthy if they are well maintained to carry out their physiological functions have high ecological resistance to pests and other external factors [7].

Assessment of tree damage has developed rapidly. For example, the Forest Health Monitoring (FHM) technique [8] helps determine tree damage that occurs in trees in several forest functions [9]. Damage to forest stands has a spatial dimension, and trend analysis can be based on the geographical aspect of the land. Several studies on the direction of land topography in explaining a particular phenomenon have been carried out, for example, by [10] on the distribution of codot coffee [11] on daily roaming of...
elephants in Bukit Barisan Selatan National Park and [12] on an analysis of the distribution of elephants in Way Kambas National Park. Geographic Information Systems is vital where the spatial distribution of geographic phenomena, including nature and characteristics, is well described. This research is needed to clarify the spatial health condition of the forest so that the hope is to find out trends in forest health on several land topographic variables. This study aims to determine the landscape characteristics at various levels of damage to stands in cluster plots in three forest functions.

2. Materials and Methods

2.1. Study Area

This research is an analysis of existing research, and the study was carried out for four months from January to April 2021 in the Protected Forest in the management of the Beringin Jaya Community Forest (HKm), the Lestari Jaya Forest Farmers Group 8, Conservation Forest (Tahura Wan Abdul Rachman). Meanwhile, the Production Forest location in Batang Hari District, East Lampung (figure 1).

Protected forest lands that apply the HKm scheme following existing regulations may carry out agroforestry cropping patterns, provided that high canopy plants must dominate more so that the primary function of protected forests is maintained [13]. An altitude of 250 meters above sea level will easily find the amount of land being actively cultivated by farmers, starting from the forest area to the natural forest above it to an altitude of 1,000 masl.

The forest conservation area managed by Community Forest System (CFS) Lestari in Tahura WAR is a collection block for plants and animals [14]. The slope level ranges from 5-40º and is at an altitude of 250-300 masl. The CFS Lestari management area has a wet tropical climate, and the average temperature reaches 20-29º C with rainfall ranging from 2500-3000 mm / year.

The Production Forest is a Community Forest that is managed directly by the local farming community. Community forest management uses several cropping patterns: agroforestry, monoculture, and polyculture. The slope of 0-8º is in monoculture and polyculture cropping patterns, while agroforestry cropping patterns are in slopes of 8-15º. Altitudes range from 20 masl on land managed by farmers to a height of 65 masl.

2.2. Materials and tools
The materials used in this research are the administrative spatial data of Lampung Province, HKm Beringin Jaya, Tahura Wan Abdul Rachman. Citra Digital Elevation Model (DEM) National (8 m resolution) [15] and road maps (download directly at https://tanahair.indonesia.go.id/portal-web). The tool used in this study is a handheld Global Navigation Satellite System (GNSS) to retrieve point coordinates cluster plot and determine the cardinal directions and a laptop equipped with ArcGIS 10.6 software to map stand damage to cluster plots.

2.3. Data Collection Stage
The data collected is used as input or data input consisting of:
1. Spatial data (raster and vector), including DEM imagery National year 2018 with 0.27-arcsecond resolution (download directly <ntides.big.go.id/DEMNAS/>), Provincial administrative map (source BKPH Lampung Province), administrative map HKm Beringin Jaya (source KPH North Kota Agung). Map Tahura Wan Abdul Rachman (source UPT Tahura Wan Abdul Rachman), and road maps (download directly at <https://tanahair.indonesia.go.id/portal-web> scale 1: 25.000).
2. Field data, including data on plot cluster coordinate points for each forest function.

2.3.1. Data Analysis. Data processing and analysis were carried out at the location points of the forest health cluster plots as follows:
1. Damage Assessment
The damage assessment used criteria based on the FHM method. [3] Explained that to determine the condition of tree damage, it is necessary to calculate the damage index (IK). Damage is calculated based on tree damage in each cluster of plots to obtain the standing damage index value in the cluster plot.
Damage index of FHM plot cluster level

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(CLJ)CLI = \sum \frac{PLI}{n_{plot}}
\]

Description: CLI (Cluster plot Level Index) PLI (Plot Level Index)

2.3.2. Spasial Data Analysis. Spatial data analysis is needed to determine the level of stand damage in cluster plots on-road distance, slope, and height. The method used is Near Distance, which determines the object's length (plot cluster points) from the road. To create advanced theme grids can do with spatial facilities using near distances (measurement values closest to furthest reaches from objects) [9,10]. Analyzing cluster plot points on land slope and elevation can use extract values to point.

3. Results and Discussion
3.1. Stand Damage Index in Clusters Plot Protected Forest
Based on the highest CLI score of the study [16], damage occurs in cluster plot 1 with a value of 4.94, cluster plot 2 with a value of 4.83, cluster plot 3 with a value of 3.26, cluster plot 4 with a value of 3.50, cluster plot 5 with a value of 2.36 and cluster plot 6 with a value of 3.21. The trend of stand damage to the distance from the road can be seen in figure 2a. The distribution of each cluster can be seen in figure 3a. The tendency of stand damage in the cluster plot to the slope of the land can be seen directly in figure 2b. Figure 3b shows the distribution of clusters in the land slope data. The trend of stand damage to land height can be seen directly in figure 2c and figure 3c. The distribution of plots domination at an altitude of 900-1100 masl, namely in cluster plot 3, cluster plot 4, cluster plot 5, and cluster plot 6.
Figure 2. Trend damage to stands on cluster plots in a protected forest; (a) to distance from the road, (b) to the slope, (c) to land height.

Figure 3. Distribution cluster plot in a protected forest; (a) of the nearest road, (b) based on the slope of the land, (c) based on elevation.

Road distance at a distance of 0-200 m in cluster plot 3, for a road distance of 201-400 m in cluster plot 4, road distance at 401-600 m is in cluster plot 5, and road distance conditions at 601-800 are in cluster plot 6. Meanwhile, the road distance of 801-1000 is in cluster plots 1 and 2. The results showed that the distance from the highway had no significant effect on tree damage. The tremendous damage occurred in clusters far from the road due to the conversion of land to coffee plantations so that fewer trees were found and caused damage. This is reflected in the results of this study, which showed that distance from the highway had no significant effect on tree damage. This result can be seen from the R2 (R-square) value of 0.12 (12%). Other factors cause damage, such as inadequate management conditions that cause direct disturbance to tree conditions [17]. According to [18], many human forest management
activities currently cause various disorders, such as injuring a tree with a sharp object that can cause open wounds found in the form of peeling tree bark [8].

The trend of stand damage to the hill denotes a negative linear relationship, and the higher the slope class, the lower the level of tree damage. This relationship is significant, seen from the R-square value is 0.85 (85%). This result is consistent with the statement of [19] stated that variations in endophytic assemblages were related to environmental gradients (slope altitude, rainfall, and temperature) [20].

Plot clusters at an altitude> 1300 masl—namely collection plot 1 and cluster plot 2. The trend of damage to stands against height has a negative linear relationship. The higher the place, the lower the damage to trees with an R-square value of 0.86 (86%). This investigation is by [21] that the elevation factor influences the variety of illness spread the distinction between the assortments of phyllosphere organisms increments with the distance between the leaves in the tree shade (a contextual analysis of Fagus sylvatica). As per [22], Geographical conditions in swamps describe high temperatures and oxygen. While in the high countries, a great deal influences the diminishing in gaseous tension and air temperature to influence nuisances and infections development.

3.2. Stand Damage Index in Clusters Plot Conservation Forest

Based on the CLI analysis, [23] the largest occurred in cluster plot 6 with a value of 3.51 followed by cluster plot 2 with a value of 2.89, cluster plot 1 with a value of 2.61, cluster plot 3 with a value of 2.60, cluster plot 5 with a value of 1.99 and lowest damage on cluster plot 4 with 1.56. The trend of stand damage at a distance from the road can be seen directly in figure 4a. The distribution of the cluster plots from the nearest road can be seen directly in figure 5a. The trend of stand damage in the plot cluster to the land slope can be seen directly in figure 4b, and the distribution of cluster plots based on the hill can be seen directly in figure 5b. Based on the analysis (figure 4c and figure 5c). The distribution of plots at an altitude of 100-200 masl, namely in cluster plot 1, a length of 200-300 masl, cluster plots 2 and 3 plots, stand to height has a positive linear relationship.

Figure 4. Trend damage to stands on cluster plots in conservation forest; (a) to distance from the road, (b) to the slope, (c) to land height.
Figure 5. Distribution cluster plot in conservation forest; (a) of the nearest road, (b) based on the slope of the land, (c) based on elevation.

The most significant damage found in cluster 6 occurred due to the condition of the old stands. Following [24], trees attacked by pests and diseases are usually old trees, which reduces the tree's metabolism. The farther the distance from the road will result in significant damage with an R-square value of 0.98 (98%). The results showed that it was different from research [25] in the land-use conservation of land distance which shows no significant effect between the number of plant types for a land far and near so that people intensively manage their land.

The tendency for stand damage against the pitch showed an insignificant relationship with an R-square value of 0.9 (9%). This result is not following research [26] that the slope of the land is more easily disturbed or damaged due to rainfall which can cause soil erosion and loss of fertile topsoil.

The height of a place will affect the damage to the yield trees. This result is the same as the analysis in a protected forest, where altitude affects significant damage that affects tree damage, which can see from the R-square value of 0.96 (96%). The results of this study differ from research [7] that the effect of altitude is not significant. Apart from the natural factors of old trees obtained from the observation, tree damage to the landscape can also be affected by tree genetic variation.

3.3. Stand Damage Index in Clusters Plot Production Forest

Based on research analysis [28]. The most significant damage can be seen directly on the 6 cluster plot, with a value of 7.70. The subsequent damage occurred in cluster plot 4 with a value of 3.30. Cluster plot 2, cluster plot 3, and cluster plot 5 with the same value, namely 2.50, and the lowest is cluster 1 with a value of 2.00. The trend of the level of stand damage to the distance from the road can be seen directly in figure 6a. The distribution of the plot cluster from the nearest road can be seen directly in figure 7a. The trend of stand damage in the plot cluster to the land slope can be seen directly in figure 6b. The condition of the plot cluster for land slope in the highest observation occurs in cluster 6 with the flat slope class conditions as shown in figure 7b. The trend of damage to stands in the plot cluster at height can be seen directly in figure 6c. The distribution of cluster plots for height (figure 7c) is in the same vulnerable class, namely <500 masl.
Figure 6. Trend damage to stands on cluster plots in production forest; (a) to distance from the road, (b) to the slope, (c) to land height.

Figure 7. Distribution cluster plot in production forest; (a) of the nearest road, (b) based on the slope of the land, (c) based on elevation.

The dominating road distance occurs at 0-200 m in cluster plot 3, cluster plot 4, cluster plot 5, and cluster plot 6. As for the road distance, 201-400 m is in cluster plot 2, and the road distance conditions are at 401-600 m is in cluster plot 1. The result of the trend of stands against the distance from the road denotes a negative linear relationship. The closer the plot distance from the road, the higher the damage. The R-square value is 0.78 (78%). The biggest damage that occurred in cluster plot 6 was caused by biotic factors (human mushroom) and abiotic (temperature light humidity)so that the damage is greater than other plot clusters [29]. A further issue is boundless (yet to differing degrees) human effect on woods because of silviculture and slopes in land-use force connected to forest health [30, 31].
The land slope condition shows 0-8% slope dominance with flat slope classes in cluster plot 1, plot cluster 2, plot cluster 3, and plot clusters 6. While for slopes 8-15%, gentle slope classes are in cluster plot 4 and cluster plot 5. Regression results show that slope does not affect tree damage with R-square is 0.40 (40%). The hill does not affect the pitch due to the general conditions in the observation that do not differ significantly, so the damage caused is not accurate. The explanation in the research of [32] is that slope does not affect pitch due to intensive land use by local farmers.

The results of the tendency for stand damage to height denotes a negative linear relationship. Low height tends to damage tall trees, which can be seen directly from the damage's significant effect with an R-square value of 0.71 (71%). According to [33], the height difference provides a real difference in the microclimate. The differences that occur include humidity and air temperature. These factors are components of the microclimate that significantly affect plant growth, and each of them is related to creating optimal environmental conditions for plants.

4. Conclusion

Due to the distance from the road, the damage tends to be further from the road, causing more significant damage to stands. Considerable damage occurred in conservation forest, not protection forest and production forest, which reached 98%. Slopes have a significant damage effect. The higher the hill, the more damage the stand will be. Slopes of 25-40% (steep) have a substantial impact on protection forest with a percentage of 85%. Height has no considerable effect whereas low height has considerable stand damage—significant damage to production forests <500 masl.

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