The detection and monitoring the tree health of *Swietenia macrophylla* in University of Sumatera Utara's (USU) campus area

A Susilowati[1], A G Ahmad[1], V Silalahi[1] and H H Rachmat[2]
[1]Faculty of Forestry, Universitas Sumatera Utara. Jln Tridharma Ujung No 1, Kampus USU. Medan. North Sumatra Indonesia. 20155
[2] Forest Research, Development and Inovation Agency. Ministry of Environment and Forestry. Jln Raya Gunung Batu. Bogor, West Java

E-mail: arida_iswanto@yahoo.co.id

Abstract. Mahagony (*Swietenia macrophylla*) is an important tree in USU campus as greenline and education forest and as much as 1054 trees were found here. The method of Forest Health Monitoring (FHM) is one of the ways to assess the health status of the tree. The objective of this research was to evaluate the health status of mahagony trees in the USU campus area. 1054 trees were evaluated for their health using FHM Methods. FHM method was applicated through a series of tree damage observation. This study showed that 9 types of damage were found in this research, those were cancer (0,47%), konk or decayed further (1,99%), open wound (0,37%), brum (0,66%), broken and dead branches (25,33%), brum in canopy (0,75), crown dieback (0,75%) and leaves damage (25,33%). Result showed that 372 tree (35,29%) was in healthy condition, while 531 tree (50,34%) was in moderate damage and 148 tree (14,07%) was in serious damage. Based on the Level Damage Index, most of the health status of mahagony trees in USU campus was moderate, it indicated that maintenance activities were required to prevent greater damaged.

1. Introduction

University of Sumatera Utara (USU) Campus area is one of the green open spaces in Medan that provides ecological, social, cultural and aesthetic benefits for campus residents and neighboring communities. There are several scattered green open space areas at USU campus with different tree and plant combination. Nevertheless, mahogany is one of the distributed tree species in the green open space area of USU Medan campus with an equal distribution in almost every campus location. Our previous survey discovered 1054 trees in the USU campus area.

Swietenia macrophylla or known as big leaf mahagony is a large tree with a height reaching 30-40 m, but when the habitat is favorable, the tree height can reach 60 m. The bole is cylindrical and straight, buttress in the lower part if its rough bark with small patches flaking [1]. Mahogany trees do not need specific soil type requirements, mahogany can naturally grow in alluvial soil types, volcanic soils, lateric soils, and soil with a high clay content [2]. Therefore, this tree grows well and became dominant at USU campus.

Oftenly, broken branches and fallen trees occur in the USU Campus which indicates that many trees are in damaged conditions, without exception for mahagony trees. Therefore it is necessary to monitor the condition of the tree to avoid the unpredictable incidence and also to provide recommendation of maintenance activities to protect the tree's health condition.

Tree damage is an indicator or a sign that trees are in fit or unfit condition. Healthy trees are able to conduct their physiological functions as well [3]. They also have high ecological resistance to pests and other external factors. The presence of air pollution, human activities, biological factors and the

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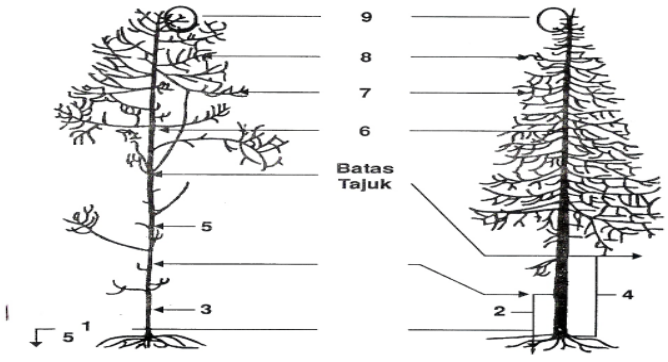
age of trees can lead to a decline in the health of trees. The deterioration of tree health can be observed from the level of damage. The damaged trees can be caused by pests, weeds, fire, weather, animals or human activities. Tree damage can be detected early through the level of damage assessed from the aspects of type, location and the severity of damage. According to these considerations, this research was conducted to identify the number and distribution of the health level of mahogany trees in University of Sumatera Utara (USU) Campus.

2. Materials and methods

Research and monitoring on the mahagony's tree health was conducted at the Campus of University of Sumatera Utara, Padang Bulan, North Sumatra. A total of 1054 mahogany trees on the green line were observed. The observation and measurement of the health condition consisted of all parts of the trees from root to the canopy. All trees coordinate plots using Global Positioning System (GPS) for their spatial distribution.

Tree health measurements were conducted based on the USDA Forest Health Monitoring (USDA FHM) method [4]. USDA FHM method was a progressive method and procedures and has been widely practiced, especially, in US Forest areas. It is widely-known as a relatively new technique in monitoring forest health and its sustainability especially in temperate regions, but recently this method also is applied in tropical regions. Furthermore [5] it was stated that there are 4 (four) indicators for tropical forest health monitoring which are forest production, biodiversity, vitality and forest health and also site quality. The first step of the USDA FHM method is detection and monitoring. Detection and monitoring was conducted to identify the type of ecosystem damage and disturbance through a series of monitoring and recording trees damage [6]. For this purpose, the observed parameter for the mahagony health monitoring were: damage location, damage type and damage severity level. The observed signs and symptoms were used to record any damage and catastrophic assessment.

The damage location were categories using a one-digit numeric code ranging from 01 to 9 (figure 1) according to the Environmental Monitoring and Assessment Program (EMAP). The codification was applied based on the part of trees which were damaged. For example, code 01 was applied when the damage location was in the root part and code 02 for the root and the lower bole.



01: root part
02: root and lower bole
03: lower bole
04: lower and upper bole
05: upper bole
06: crown stem
07: branch
08: shoot
09: leaf

Figure 1. Damage location codification of EMAP (USDA FHM 1997).

The damage type (table 1) was recorded by using a numerical code, which denotes from damage type 01 till 25. For example is the open wound. Open wound is an opening or series of opening where the bark has been removed or the inner wood has been exposed. For this damage type, code 03 was applied. The severity damage level was coded by using data from the recorded damage type. Details of used and description of location, damage and severity code, provided in the Forest Health Monitoring Field Methods Guide [4].

Table 1. The code and damage type codification based on EMAP.

No	Damage type	Saverity level (10% - 99%)	Code
1	Cancer/gall	20%	1
2	Konk/decay further	Nil*	2
3	Open wound	20%	3
4	Exudation (gumosis and resinosis)	20%	4
5	Broken branches less than 0.91 cm	Nil*	11
6	Brum in root and bole	Nil*	12
7	Broken root and dieback less than 0.91 cm	20%	13
8	Crown dieback	1%	21
9	Broken and die branch	20%	22
10	Brum in crown	20%	23
11	leaf damage	20%	24
12	leaf discolourization	30%	25

In case a multiple damage occurs in the same location, only the most severe damage will be recorded. The number of damage recorded to each tree was three types of heavy damage. Furthermore, coding the damage to the parts of the tree is carried out by codification according to the standards of the Environmental Monitoring and Assessment Program (EMAP). The data obtained from the damage assessment then processed to get the value of Level Damage Index (LDI) using equation (1)

$$\mathrm{LDI} = \sum_{i=1}^{n} (\mathrm{xi.\,yi.\,zi}) \quad (1)$$

LDI: Value of damage index; xi: value of damage type; yi:value of damage location; zi: value of severity damage. Based on the LDI value, the damage classified into four categories those were Healthy (ILD: 0 ≤ 5), Lower damage (ILD: 6 - 10), Moderate damage (ILD: 11 - 15) and Heavy damage (ILD: 16 ≥ 21).

3. Results and Discussion

Damage caused by pathogens, insects, air pollution and other natural and man- made activities can affect the growth and development of the trees. Damage caused by any of these agents, either individually or from a combination, can significantly affect the tree health. Identifying the signs and symptoms of damage provides valuable information concerning the trees conditions [7]. The measurement of damage indicator involves the damage location, the type of damage and the damage severity. Each indicator is evaluated, coded, classified and analyzed to find a conclusive recommendation. Based on the observation, it shows that most of the mahogany trees in USU campus are in a damaged condition. Tree damage (depending on location, type and severity) will affect the physiological function of the trees, a decreased growth rate and can cause tree death [8].

3.1. Type of damage

According to USDA FHM there are 12 types of tree damage. Based on the observation of mahagony, 9 types of damage found in mahagony trees were cancer (figure 3a), konk or further decay (figure 3b), open wounds (figure 3c), brum (figure 3d), crown dieback (figure 3e), broken branch (figure 3f), brum in the canopy (figure 3g), leaf damage (figure 3h) and the change of leaf color (figure 3i). From 1054 mahagony trees (figure 2), broken branch (code 22) and leaf damage (code 24) was the highest type of damage which have occured with a total number of 297 trees (25,33%) followed by leaf discolorization (code 25) with 94 trees (8.91%). Open wound (code 3) was a rare damage which has occured in the mahagony to only 4 trees (0.37%).

The frequency of broken branches in mahagony trees is assumed to be caused by wind and tight spacing. Wind and space are two important factors which commonly causes broken branches. According to [9], trees with less tapered and branches are easy to fail or suffer damage after being blown by wind.

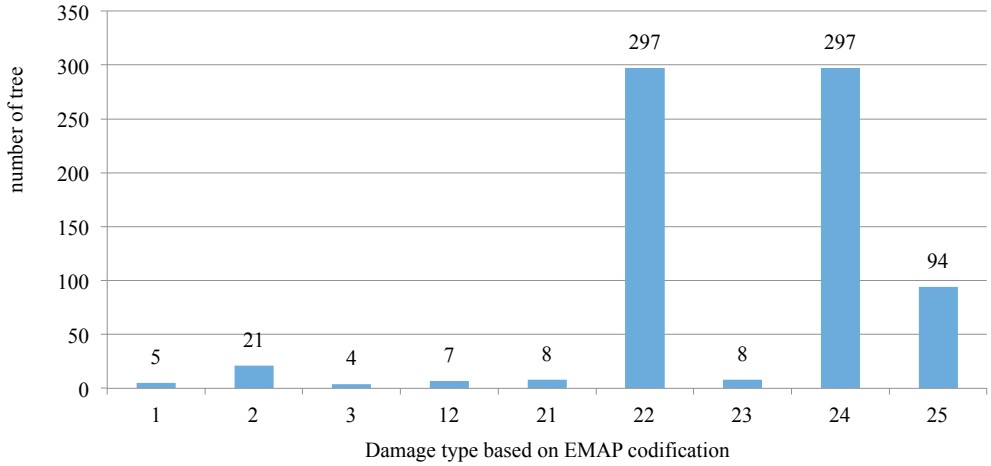


Figure 2. Number of tree based on the type of damage.

Wide spacing and stand thinning will result on good bole trees but less susceptible to injure and breaking compared to poor taper trees [8]. Furthermore [9] it is stated that pruning activities by reducing length of certain tree branches create a lower center of gravity and help trees to avoid windstorms. It is concluded that reducing the entire crown size will also reduce the potential damage.

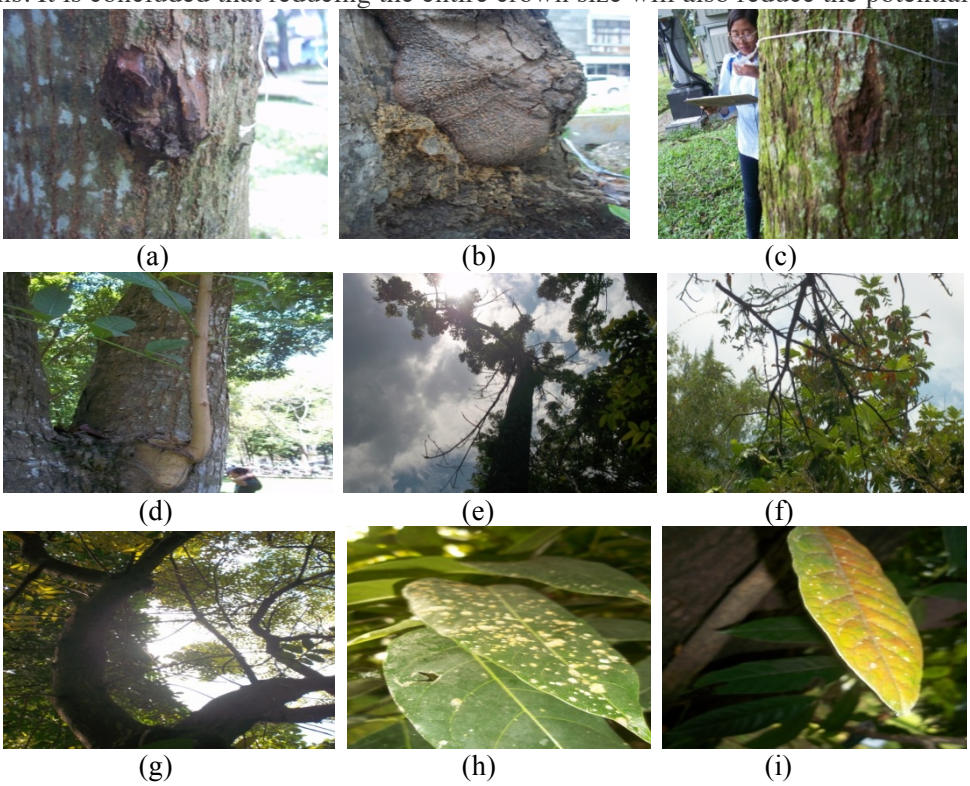


Figure 3. Type of damage on mahagony tree. Cancer (a), konk (b), open wound (c), stem brum (d), crown dieback (e), broken branch (f), branch brum (g), leaf damage (h), leaf change colour (i).

Leaf damage is assumed to be caused by human activities (e.g. student's activities), pest, disease and tight spacing. Human activities also cause damage to the leaves of the mahagony, it can be shown on fallen young leaves surrounding the tress. Leaf damages caused by fungal pathogen are also

stressed in this research determined by the sign of the leaf spot (figure 3h). Fungal leaf spots will usually have dry textures. Insect feeds (beetles) also causes ragged/chewed or missing leaves on the mahagony.

3.2. Damage location

According to USDA FHM, there were 9 damage locations. Observations showed that damage locations on the mahagony trees varied (figure 4). The most common damage location was the leaf part (code 9) with 357 trees (33.9%), followed by branches (code 7) with 273 trees (25.9%) and the lowest was shoot part (code 8) with 1 tree (0.38%).

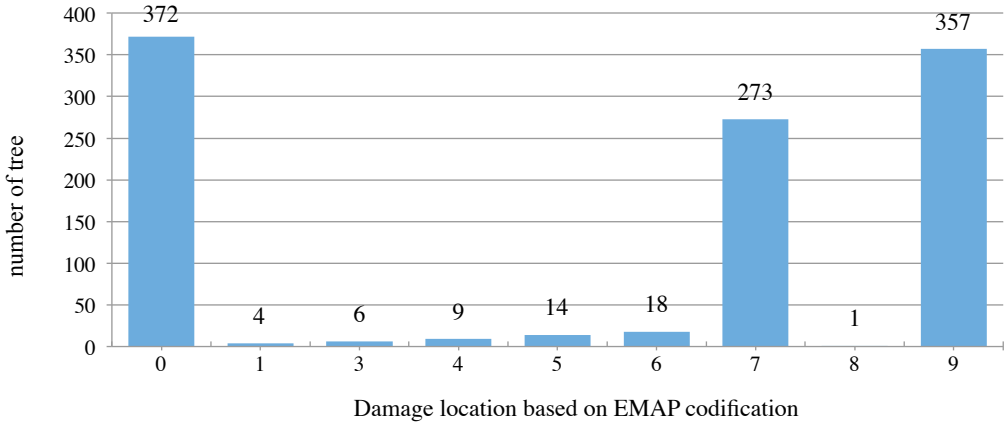


Figure 4. Tree damage based on its location.

Leaf is where the most common damage occurs to the mahagony tree. The main function of leaf for the plants is producing sugar and carbohydrates. Sugar and carbohydrate are basic compounds and energy supply for metabolic pathways in providing energy for growth, root development, flower and seed production, and also for disease resistance [3]. The damaged leaf can not hold those functions and will reduce its photosynthesis capacity. On mahagony trees, leaf spot diseases are often found in observed trees. Although leaf spot diseases occurs on small percentage of the tree's leaf area but it will disrupt the host trees by disrupting the process of photosynthesis. If the disease spot covered all part of the leaf it will cause serious damage, reducing the tree growth and probably causing tree death. When it occurs during the growing stage, leaf spot disease will reduce the growth and increase it susceptibility toward pest infestation and disease.

3.3. Damage severity

The severity of damage to the mahogany on USU campus varied (figure 5). Based on the most common severity classes are 1-9% (code 0) with 351 trees (33.3%), then class 20-29% (code 2) with 315 trees (33.3%), 30-39% (code 3) class with 180 trees (17.1%). While the least class of severity is class 60-69% (code 6) with 13 trees (1.2%) and 70-79% (code 7) with 13 trees (1.2%). According to [12] the damage severity related to the age of tree. Old trees with a wide stem diameter oftenly breaks and infested by pest compared to those of young trees with smaller diameters.

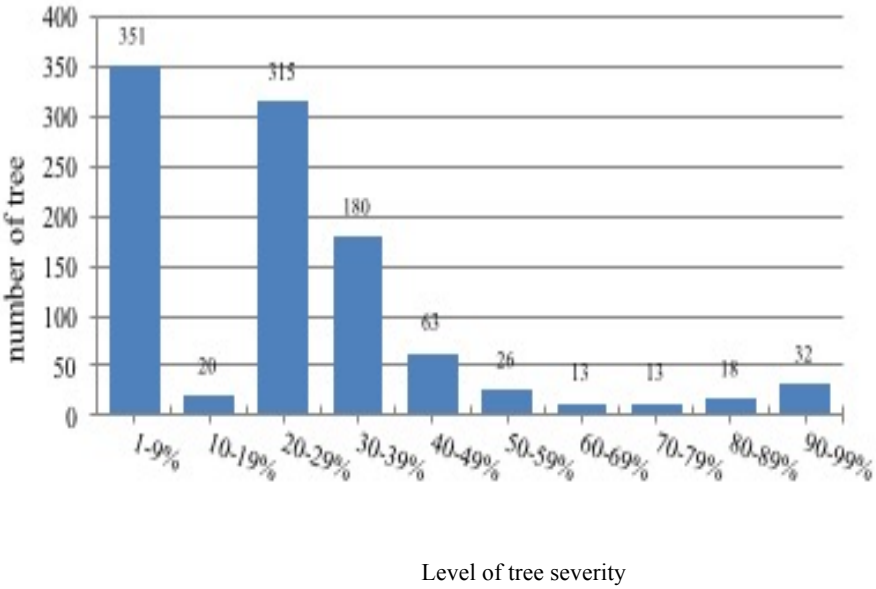


Figure 5. Number of tree damage based on level of tree severity.

Human activity becomes one factors which cause damaged trees in USU Campus area, such as improper branch pruning and advertising by using nails. This can cause injuries to trees that become the location of other diseases that spread and cause trees not to grow well and become unhealthy. Many trees at an unhealthy level indicates that intensive maintenance should be done to avoid unfavorable impact on humans such as fallen trees, broken branches and others.

3.4. Level Damage Index

The Level Damage Index was quantified by using a statistical formula based on the value of type of damage, the location of damage and the damage severity. The results showed that 375 trees (35%) are in healthy condition, 531 trees (50.38%) on moderate damage and 148 trees (14.7%) on heavy damage (figure 6).

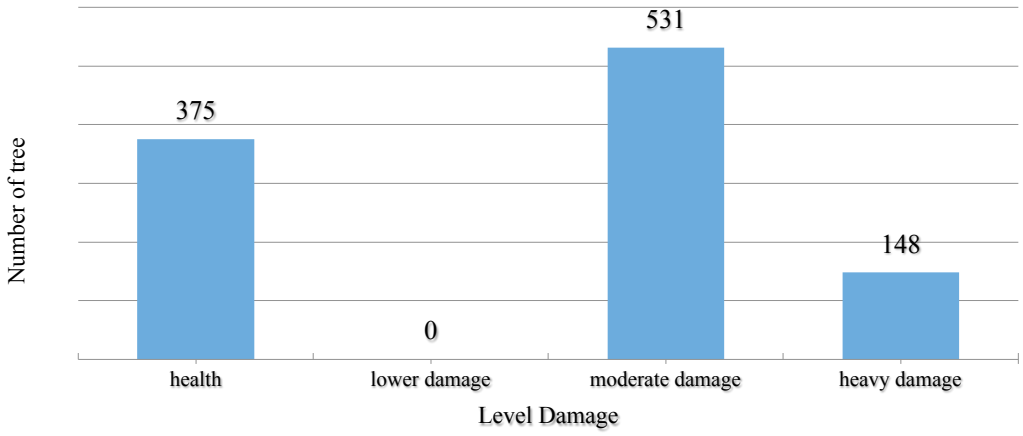


Figure 6. Level damage index.

Based on this result, maintenance activities are required to prevent further damage. Pruning is required for maintaining mahagony trees in the USU campus areas. The objective of pruning is to optimize light interception and direct the growth and development of the branches and shoots in a favorable direction. Light interception plays an important role in total assimilation formation through photosynthesis and a partition of assimilation. Furthermore [12] it is stated that appropriate pruning should be taken to remove unproductive, hazardous and dead branches to optimize the interception of light and to control the canopy form.

The presence of yellow leaves is due to the lack of plant nutrients. Effective fertilization is required to maintain the health condition of shade trees. Young leaves and yellow leaf vain are the characteristics of a nitrogen deficiency phenomena. Symptoms of nitrogen nutrient deficiency are characterized by the yellow color in the leaf and vein followed by the necrosis from basal to apical leaves [13]. The application of NPK fertilizer should be done effectively to improve the health condition of plants.

The tree damage on the greenline mainly is caused by human actions. Vandalism by slashing the tree bark on the stem and branches is a dishonorable act. The accumulation of municipal solid waste near the tree also will attract other organisms [14]. The waste accumulation can also increase excessive moisture, so its condition will support fungus growth [5].

4. Conclusion

According to the level damage index (LDI), most of the Mahagony trees at USU campus is categorized into moderate damage (50.38%). The highest damage location (33.9%) was located in the leaf part. Broken branches and leaf damage were the most common type of damage on the mahagony trees (25.33%). Based on this research, tree maintenance activities through regular branch pruning and fertilization are required to avoid further damage. Environmental education is also required to prevent vandalism that causes injuries to the trees and leads to the death of trees.

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