Tree Health Analyzing of *Malvaceae* Collections in Bogor Botanical Gardens

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**Abstract.** Center for Plant Conservation Botanic Gardens (Bogor Botanical Gardens) is an ex-situ conservation center in Indonesia which has ± 13,000 plants specimens collection in shrubs, herbs, lianas and trees. The collection is classified in 218 families, which one is Malvaceae. Most of Malvaceae collections at Bogor Botanical Gardens is tree shaped. Trees have risk of fracture, failure or death which can cause harm. The aim of this research is determining the health condition of Malvaceae collection to predict the occurrence of damage (broken, failure, dead etc.) and as a consideration for collection collections treatment. The method which used are combination of visual observation methods and sound waves using arborsonic. Total samples measured are 7 trees which have criteria such as being in a location with high visitor accessibility, large diameter, old tree and visible disease or pest attack. Each sample was done visually and checked with arborsonic basically using sound wave. The point of measuring on the tree is depend on initial identification of damage using a rubber hammer. In this research can be concluded, there are 2 trees which high risk of damage and become first priority handling because has percentage of damage above 60%, 5 trees have medium risk with second priority (30-60%).

1. **Introduction**

Urban environmental problems are widely discussed, one of them is related to air pollution. Vegetation as one of pollutant absorbers is an important actors to minimize these problems. Therefore, in urban development there should be established a vegetated green area reaches 30% from total area. Area can be formed such as city forest, city park, botanical garden or green area on road or river border. Nowak [14] states that shade trees in urban areas act as city identities, air pollution absorbers, noise absorbers, city air conditioners, wind filters, soil conservation and city ornament. Leaves can absorb noise up to 95%. The most effective types of plants to reduce sound are those which have thick canopy with shady leaves [2]. Botanical Garden is an areas with high vegetation cover certainly has real contribution to reduce air pollution problem in urban areas. In accordance with one of its functions written in Perpres No. 93 Th 2011, namely Environmental Services, Bogor Botanical Gardens have a major role in pollution absorption in Bogor City. The existence of the Botanical Gardens in Bogor City is estimated potential to absorb 134.61 tons / year of carbon [18] with potential carbon stocks reaching 17,064.7 tons
[16]. In another side, existence of vegetated areas in the city be able to create a comfortable microclimate, regulated preparation to increase city's carrying capacity for life.

The role of urban vegetation areas is quite high, but not without problems. Center for Plant Conservation Botanic Gardens – Indonesian Institute of Sciences (PKT KR – LIPI) or well known as Bogor Botanical Garden is an ex-situ plant conservation area where ± 13,000 plants are collected and majority of collections are trees. Trees which planted in green open area have fall potential. Tree collections have some different characters compare the other collections. Tree has larger dimension than other plants and can reach older. However, tree collections has some flaws that could result some material harm and other losses. There are no trees that are completely safe, considering the possibility of very strong winds can damage or subvert trees mechanically. Therefore, trees can usually identified if there are some dangers from defects or fallen-prone trees characteristics [10, 17]. This cannot be separated from sick condition due to old age, limited soil nutrient content or non-optimal care. These factors have potential to increase likelihood of trees being attacked by diseases, insects or other damage.

Bogor Botanical Gardens have collections that are classified in 218 families, one of this is Malvaceae. Malvaceae collections are mostly trees collections with old age and big size. Old age collections have breaking risk, collapsing and dying higher which can cause losses. In addition, large dimensions tree can cause massive damage if collapses and hit objects around. As one of tourist attractions with have high visit intensity, fallen trees will be dangerous for visitors safety in Botanical Gardens. Therefore, observation of potential trees fall is very important thing to do, one of them is Malvaceae family. Trees health inspection and monitoring in accordance with rules of silviculture to maintain tree's health by performing steps of controlling, facilitating, protecting and salvaging [15].

The aim of this research is determining trees health condition of Malvaceae collections to predict the occurrence of damage (broken, failure, dead etc.) and as a consideration for malvaceae collections treatment.

2. Material and Methods

2.1. Location
This research located in Bogor Botanical Gardens (S: 06 0 36’155”, E: 106 0 47’825”) altitude 291 m above sea level. Tree health assessment of Malvaceae was held on May - August 2015. Trees which give assessment using arborsonic located at several area in BBG. Total samples measured are 7 trees which have some criteria such as being in a location with high visitor accessibility, large diameter, old tree and visible disease or pest attack.

2.2. Material and Equipment
The methods were used in this research is arborsonic. The most effective technology for detecting tree decay by using an ultrasonic tomograph. This technology can determine the anomalies position and estimating tree trunks size and shape [13]. Tools were used are arborsonic equipment set (sensors, hammer and computer with arborsonic software), rubber hammer, and diameter tape. Assessment of damage by arborsonic did on 0-300 cm high of main stem. Measure level point choosen depend on sound on the stem while beaten using rubber hammer or visual assessment. After measure point of damage was decided, measuring the circumstance of stem to decided amount of sensor. Arborsonic consists of a set sensors (typically 8 to 10) that are connected to the trunk. Sound waves are produced by tapping each sensor with a small hammer. The system measures the transmission time from each impact with the hammer to each sensor. By measuring the distances between sensors, apparent sound velocities are calculated by the system software, from which wood density is determined [5].

2.3. Data Analysing
Area of decay was calculated as a percentage of squares identified as decayed divided by the total area of wood. For the tomograms, the area of decay was calculated by the arborsonic software. The tomograms consist of some colours gradient, green is indicated good condition, yellow means decay
process are beginning, red means higher decay level, blue means hollow condition. Each measured tree has a different handling priority scale depend on several conditions so treatment for every single tree could be different. Trees with higher priority would get faster and more attention treatment than low priority. Trees with high priority are trees which located at crowded area, trees with large diameter stem, old trees or visible attack of diseases and pests.

3. Material and Methods
Species of Malvaceae contained within The Plant List belong to 245 plant genera. includes 14,539 scientific plant names of species rank for the family Malvaceae. Of these 4,465 are accepted species names [8]. All Malvaceae family members there were 328 species included in the IUCN redlist. Some species of this plant are widely used by the community for cotton producers, in addition to producing wood for furniture. Bogor Botanical Garden has approximately 218 collections Malvaceae, which 72 species known and 33 collections are unknown. In this study, not all collections were observed, but samples were chosen which had large enough risk with some criteria large dimension, located in high accessibility of tourism and thought to have suffered damage (Table 1).

Table 1 shows, from 7 sample trees that were suspected of having damaged 2 of them had decay values reaching more than 60%. Sample 1 has a maximum decay of 78%, this condition is very dangerous for trees in high-accessibility locations. With damage >60% and large canopy will be very potentially failure. Sample 2 has maximum decay reaching 76%. Both of these collections are recommended to get first priority in handling. It is necessary to cut or pruning to reducing amount of load. Heavy burdens are no problem for trees if proportional and have healthy stems, but if the stem has been damaged, it is necessary to reduce the burden to prevent the occurrence of fallen or broken trees. Besides that, pruning also provides several advantages. Pruning would add more space for light to reach the ground, moisture will decrease. Affect to reduce the risk, diseases and fungi attack. Ermayasari [4] mentions, less pruning (too mild), leads to unhealthy microclimate that can increase pest and disease attacks. In addition, pruning aims to provide sufficient space, forming canopy which will increase flowering and seed production for high propagation.

| Sample | Species                     | Status   | Decay level | Maximum Decay |
|--------|-----------------------------|----------|-------------|---------------|
| 1      | Bombax valetonii Hochr.     | Collection | 150 78 200 70 300 64 | 78 |
| 2      | Bombax ceiba L.            | Collection | 120 76 200 67 280 61 | 76 |
| 3      | Ceiba pentandra (L.) Gaertn. | Collection | 50 47 130 40 208 58 | 58 |
| 4      | Bombax valetonii Hochr.     | Collection | 100 27 210 36 370 56 | 56 |
| 5      | Bombax valetonii Hochr.     | Collection | 150 24 350 50 360 47 | 50 |
| 6      | Ceiba pentandra (L.) Gaertn. | Collection | 135 47 230 49 - - | 49 |
| 7      | Bombax valetonii Hochr.     | Collection | 150 18 200 45 - - | 45 |

Note: there are 2 trees which high risk of damage and become first priority handling because has percentage of damage above 60% and 5 trees have medium risk with second priority (30-60%).

According to Rachmadiyanto [17] light pruning recommendations need to be done for trees with high accessibility categories such as near buildings, near roads and dry branches. Heavy pruning recommendations also need on trees with raised root categories, too heavy branches, unbalanced canopy. This is did in order to reduce tree canopy burden, thus minimizing risk of broken or falling trees. Pruning also aims to stimulate branching, form canopy and regulate plant height so that is easy to maintain [6].
Table 2. Priority and treatment advice for trees which have been assessed

| Priority treatment | Sample | Species | Treatment          |
|-------------------|--------|---------|--------------------|
| First priority treatment | 1      | Bombax valetonii Hochr. | Prunning / cutting |
|                    | 2      | Bombax ceiba L.          |                    |
| Second priority treatment | 3      | Ceiba pentandra (L.) Gaertn. | Regularly check/assessment |
|                    | 4      | Bombax valetonii Hochr. |                    |
|                    | 5      | Bombax valetonii Hochr. |                    |
|                    | 6      | Ceiba pentandra (L.) Gaertn. |                    |
|                    | 7      | Bombax valetonii Hochr. |                    |

Samples that have a maximum decay value <60% have two possible treatment suggestions. If maximum decay <30% tree is categorized as safe enough. Trees with maximum decay > 30% it is advisable to check regularly. From table 2 shows, the samples 3, 4, 5, 6 and 7 have a maximum decay value between 30% -60%, therefore management does no need to pruning, but it necessary give periodically check to monitor developing of damage. If damage development is not monitored will be risk, tree will be broken suddenly without prediction. This is very dangerous for public areas trees such as Bogor Botanical Gardens.

Figure 1. Crosssection picture of Bombax ceiba L. Stem by arborsonic

Figure 1 shows some example of Bombax ceiba sonic tomograph imaging using arborsonic. The green color of sonic tomograph picture shown condition of stem are solid. Yellow gradient shown
condition of stem which getting more decay and blue color one shown hollow or heavy decay. Arborsonic is a tool that can be chosen and developed for helping tree health assessment. Some products and techniques are now marketed for detecting and assessing decay in trees, reviews of which can be found in the literature [9-12]. From Figure 1, most severe damage is on layer 1 at 120 cm height and decreases at layers 2 and 1. Multilayer images can give estimates of decay by connecting some layers and same sensor points at each layer to interpreting images based on the weather conditions.

Picus Sonic Tomograph [5] and Arborsonic was developed as noninvasive method to quantify and locate wood decay. It can produce an image of internal structure solid object by recording differences speed of sound wave transmission. So it will not disturb trees and make trees infected with pests or diseases. Equipment and techniques such as the Resistograph, drilling, and increment are involved drilling through bar into the xylem [19, 1]. There may be some disadvantages associated with drilling [7]. Management of tree assessment by identifying risks early stage can reduce tree fractures or fall, and can improve handling and management efficiency. A standard of scoring system needs to be proposed to reduce subjectivity of the assessment of observations and risks. Mapping and evaluating tree which prone to fracture or falling is one of assessment systems and prioritizes handling of tree health risks [3].

4. Conclusion
In this research can be concluded, there are 2 trees with high risk of damage and become first priority handling because has percentage of damage above 60% and 5 trees have medium risk with second priority (30-60%). Advice given for treatment of 2 trees are pruning or cutting.

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