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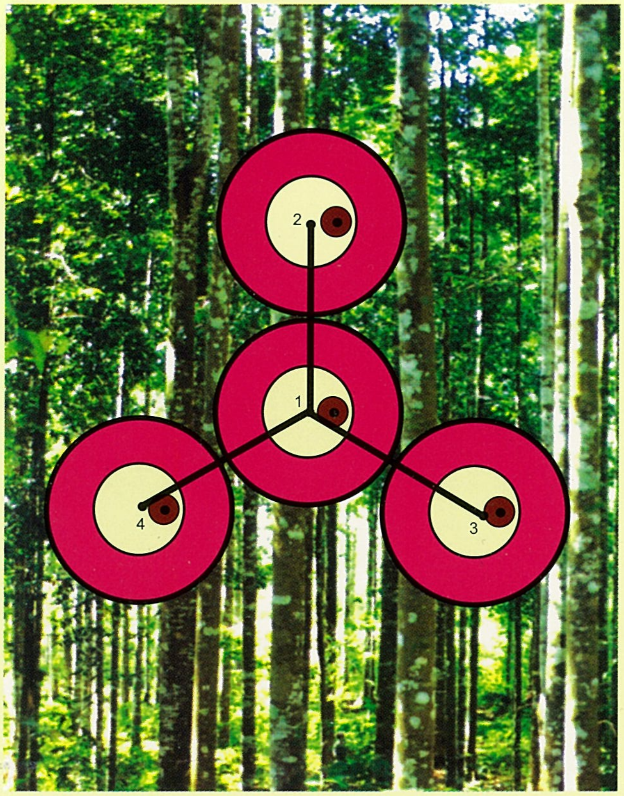
ITTO PROJECT NO. PD 16/95 REV. 2 (F)

FOREST HEALTH MONITORING TO MONITOR THE SUSTAINABILITY OF INDONESIAN TROPICAL RAIN FOREST

MOF - ITTO - SEAMEO BIOTROP - USDA Forest Service

VOLUME I



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ITTO
International Tropical Timber Organization
Yokohama, Japan

SEAMEO BIOTROP
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Bogor, Indonesia

2001

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Front Cover : Forest Health Monitoring plot model and *Shorea polyandra* plantation

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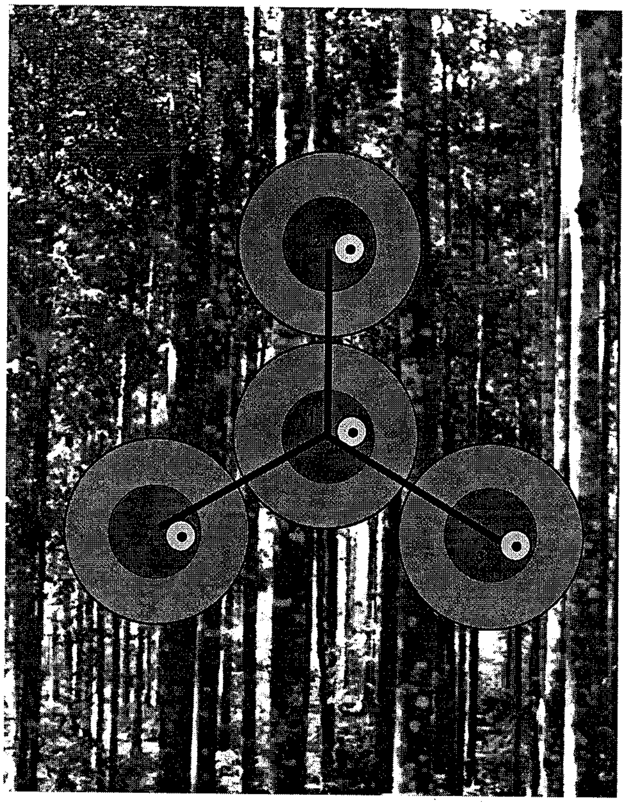

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PREFACE

Changes which occur in the forest ecosystem will always create an impact, positive as well as negative ones. Toward the implementation of ecolabelling, many forest state enterprises and the forest concession holders start reorganizing the future demands to manage forests on sustainable basis. Forests should be managed wisely according to the concept of sustainable forest management.

In 1990, ITTO (International Tropical Timber Organization) has prepared guidelines/indicators on how to manage tropical forests properly. In order to implement those guidelines, SEAMEO-BIOTROP submitted a research project proposal to ITTO entitled *Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forests*, called INDO-FHM. The objectives of INDO-FHM were to find the attributes, indicators and trends which influence the health and conservation of tropical forest; to establish monitoring plots, demonstration and training plots; technology transfer of FHM methodology and software; and to undertake training programs. Indicators used among others are: (1) Production (growth and mortality, vegetation structures, biotic and abiotic stand damage); (2) Site quality; (3) biodiversity; and (4) Forest vitality (crown structure).

Previously, research activities in Forest Health Monitoring have been carried out only in the temperate forests. Indonesia is the first country to conduct FHM research in the tropical ecosystem.

The INDO-FHM research was conducted from 1996 – 2000, with the financial support from the ITTO, USDA-Forest Service, the Ministry of Forestry of the Republic of Indonesia, and SEAMEO BIOTROP. A series of training was also conducted for the Indonesian crews (85 persons), Indonesian scientists (28 persons), and Southeast Asian scientists (14 persons).

To disseminate the knowledge and experience generated in conducting the research on Forest Health Monitoring, three volumes of Technical Reports were made.

Finally, SEAMEO BIOTROP would like to thank ITTO, USDA-Forest Service, and the Government of Indonesia for their valuable support.

SEAMEO BIOTROP
Southeast Asian Regional Centre
for Tropical Biology,

Prof. Dr. H. Sitanala Arsyad
Director

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FOREST HEALTH MONITORING PLOT ESTABLISHMENT

Technical Report No. 1

Supriyanto
Kenneth Stolte
Soekotjo
A. Ngaloken Gintings

ABSTRACT

The criteria assessed in Forest Health Monitoring are productivity, biodiversity, vitality and site conditions. The indicators selected then should be suitable for assessing the above criteria either qualitatively or quantitatively. The selected indicators must be efficient in time, cost effective and easy to apply (to detect, to record and to interpret), precisely defined and measurable. Among the indicators selected in Forest Health Monitoring (FHM) are: tree growth and structure, crown condition, damage, biodiversity, and soil properties. Data recording and measurements on all indicators are taken in a permanent plot representing the forest community of the tropical rain forest condition. This report discussed briefly the FHM plot design and the plot establishment procedure. Site-tree data, point-level area data, micro plot-understory vegetation data, and micro plot tree data are among the data collected from the FHM plots. The procedure of soil sampling and measurements are also discussed. General information related to the FHM plots established in PT. INHUTANI II, Pulau Laut, South Kalimantan; PT. Asia Log, Jambi, Sumatra; and PT. Sumpol, South Kalimantan, has also been included. FHM plots were established in virgin forest, biodiversity conservation area, buffer zone, seed production area and plantation forest.

Key words: *Forest Health Monitoring, indicators, plots, data.*

I. INTRODUCTION

In order to have information on assessment question of the sustainability of Indonesian Tropical Rain Forest for future sustainable development, a quantitative assessment of the current and future conditions of forest resources is needed. The criteria assessed in Forest Health Monitoring were productivity, biodiversity, vitality, and site conditions. The indicators should be suitable for assessing the above criteria either quantitatively or qualitatively. The selective indicators must be efficient in time and cost effective, easy to apply (to detect, to record, and to interpret), precisely defined and measurable.

Data recording and measurement must be taken in a permanent plot that represents the forest community of the tropical rain forest conditions. Therefore, the Forest Health Monitoring plots have been established in Pulau Laut, South Kalimantan, managed by PT INHUTANI II Forest Concession Holder, and in Jambi Province, Sumatra, managed by PT Asia Log Forest Concession Holder. Pulau Laut Island represents small island ecology while Sumatra represents big island ecology.

The reasons for selecting Pulau Laut and Jambi as FHM demonstration plots are as follows:

❖ The biodiversity of the big island is assumed to be bigger, and therefore plays an important role in sustainable development of tropical rain forest.

❖ Social impact on forest sustainability in the big island is higher than in small island, because of its accessibility.

❖ Fauna migration in big island is higher than in small island, that influences the ecological conditions of the island.

To test the selected indicators for Forest Health, detection monitoring plots were also established in PT Sumpol Forest Concession Holder in South Kalimantan (mainland). The detection monitoring plots were overlaid on National Forest Inventory plots that were established previously.

II. GENERAL INFORMATION OF FHM SITE PLOT

2.1. Pulau Laut

Pulau Laut is a small Island that belongs to the South Kalimantan Province. Kotabaru is the biggest town in Pulau Laut. The total area of Pulau Laut is 240.743 ha. The distance between Pulau Laut to Kalimantan Island is approximately 4.7 – 7.5 km to the South or 30 – 45 minutes by Ferry (Figure 1). Geographically, Pulau Laut is situated between 3^0 20 ' – 4^0 03' South Latitude and 116 ^{0} – 116 ^{0} 35' East Longitude.

The forest cover in Pulau Laut is 107,907 ha or 44.8 % of the total land. The vegetation type of Pulau Laut is low land tropical rain forest, dominated by Dipterocarps species, among them are *Shorea polyandra* and *Dipterocarpus caudiferus*. The forest function is divided in Permanent Production Forest (20,000 ha), Limited Production Forest (50,000 ha), Protection Forest (8,839 ha), Mangrove Forest (5,400 ha), and Conversion Forest (29,068 ha). PT INHUTANI II manages the forest area. The Indonesian selective cutting and replanting system is applied to manage those areas. The vegetation forest community in Pulau Laut Province belongs to the Tropical Rain Forest, characterized by many species, many strata, evergreen, humid, high precipitation, and temperature (Lampreck, 1989). The vegetation zone in Indonesia (Manan, 1997) is divided into three zone systems:

a. Western Zone, which is influenced by the Asian vegetation, dominated by Dipterocarp species, includes are Sumatra and Kalimantan
b. Eastern Zone, which is influenced by the Australian vegetation, includes Maluku and Nusa Tenggara

c. Transition Zone, which is influenced both by continental ecosystem dominated by Araucariaceae, Myrtaceae, and Verbenaceae, includes Java and Sulawesi islands

Pulau Laut and Sumatra consequently belong to the Western Zone.

The climate in Pulau Laut, according to Schmidt and Ferguson classification (1951), belongs to the rain type A with an average annual rainfall of 2429 – 2492 mm. The rainy season occurs from December to June, with an average monthly rainfall of more than 250 mm. The dry season occurs from July to November, with an average monthly rainfall between 100-200 mm. In most cases, there are no dry months. The average yearly temperature is 26° C and the minimum and maximum yearly temperatures are 21° C and 33° C, respectively.

The soil type of Pulau Laut is dominated by red-yellow podzolic soil, characterized by low soil pH and low phosphorus nutrient content. Topographical condition in Pulau Laut is generally flat to hilly. The highest mountain is 725 meters above sea level.

Based on the soil exploration map of the Soil Research Institute, year 1971 with a scale of 1: 1,000,000, part of the soils of Pulau Laut Utara consists of Laterite soil, which is derived from coagulated stones and intrusion physiography. The other soil type in Pulau Laut is alluvial soil.

Forest Health Monitoring Plots in Pulau Laut are located in:

a. Buffer zone (logged in 1978): Clusters 1 and 7
b. Biodiversity Conservation: Cluster 2
c. Dipterocarps Plantation: Cluster 3
d. Seed Production Areas: Clusters 4, 5, and 6.

2.2. P.T.SUMPOL

PT Sumpol is a forest concession holder located in Banjarmasin District, South Kalimantan (mainland). The total forest area of PT Sumpol is 67,000 ha. It consists of Protection Forest (3,250 ha), Limited Production Forest (21,650 ha) and Permanent Production Forest (42,100 ha). The forest is managed by applying the Indonesian Selective Cutting and Replanting System. The forest area belongs to the low land tropical rain forest, dominated by Dipterocarps species.

The slope of the area is 0 – 45 %, or flat to high. The soil is dominated by red-yellow podzolic soil. According to the Schmidt and Ferguson classification, the climate type of PT Sumpol belongs to B type with an annual rainfall of 2,485 mm. The highest rainfall is 354 mm in January. The daily temperature of the area ranges from 26°C - 33°C

The detection monitoring plots were established in Limited Production Forest. The FHM plots were overlaid on National Forest Inventory (NFI) plots. The NFI plots were established in 1993 by the Directorate General of Forest Inventory and Landuse Planning. The location of PT Sumpol is shown in Figure 1.

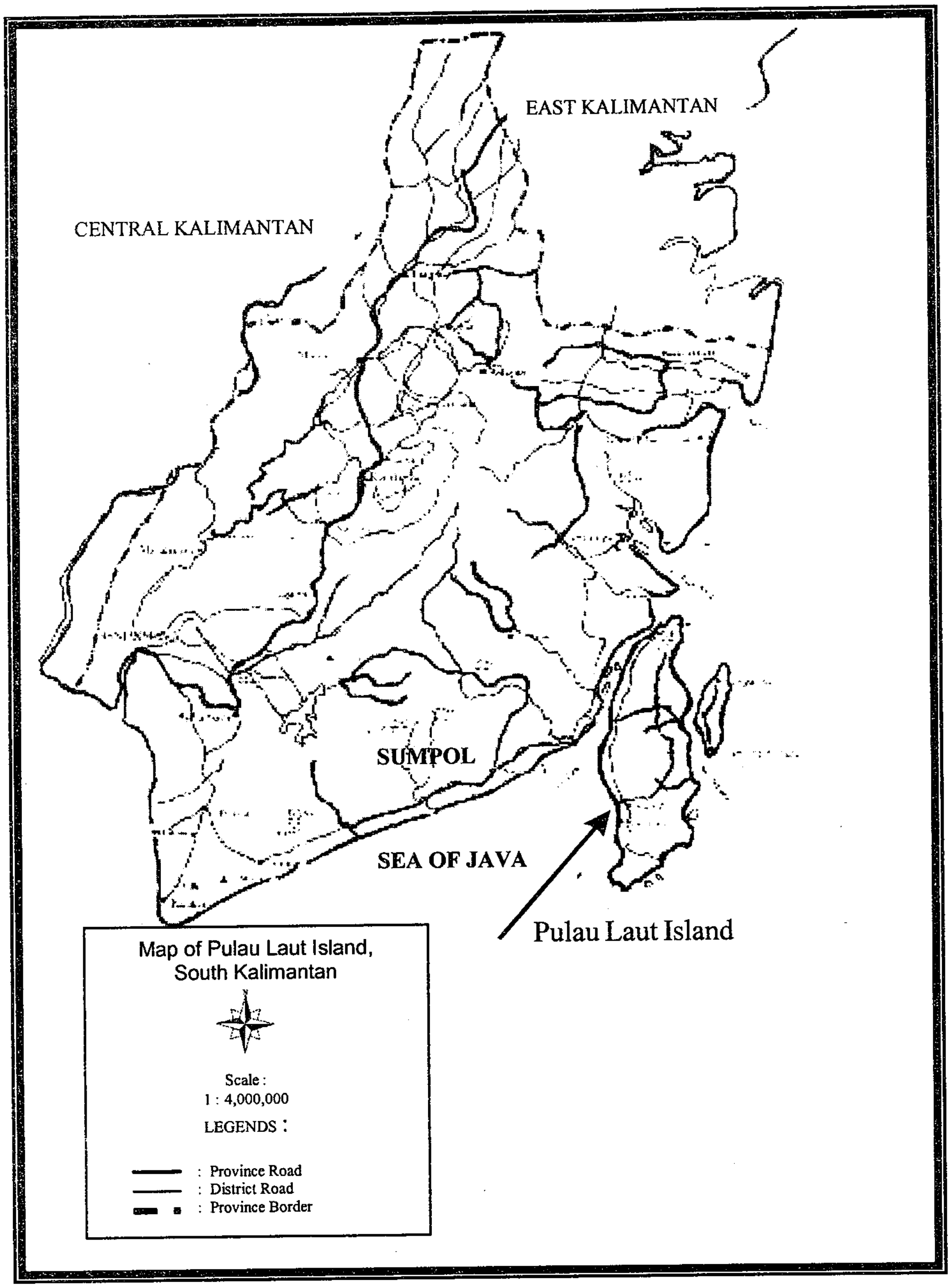

Figure 1. Map of Pulau Laut Island, South Kalimantan

2.3. JAMBI

Jambi province is situated more or less in the middle of Sumatra Island (Figure 2). FHM Plots are situated in PT Asia Log, 3 hours by car to the south of Jambi City. Jambi is one of the provinces in Sumatra found on 2° South Latitude and 103° East Longitude.

Figure 2. Location of PT Asia Log in Jambi Province, Sumatra

PT Asia Log is authorized to manage the forest based on the Decree of the Minister of Forestry No.: 116/Kpts-II/1993. The total forest area of PT Asia Log is 61,955 ha, that consists of Limited Production Forest (47,927 ha) and Permanent Production Forest (14,658 ha). The remaining virgin forest in PT Asia Log is 23,982 ha) and the secondary forest comprises 36,437 ha. Administratively, the forest area belongs to the Surolangon-Bangko District and Batanghari District.

The average temperature is 26.5° C; the rainfall is 2,248 mm per annum and the Relative Humidity is 84 %. Topography of PT Asia Log is generally flat with a slope of FHM Plots 5 – 10 %.

Soil type in PT Asia Log is dominated by red-yellow podzolic soil. Geographically, PT Asia Log is flat (0-8 % slope) to hilly (8 % - 25 % slope).

The vegetation in Sumatra belongs to Western Zone, dominated by Dipterocarps species; among them *Shorea selanica, Shorea parvifolia, Hopea odorata, Dipterocarpus* sp. The Indonesian selective cutting and replanting system is being applied in managing the forest areas. The Forest Health Monitoring Plots in Jambi are located in Limited Production Forest.

III. PLOT DESIGN AND FHM PLOT ESTABLISHMENT

The INDO-FHM plot design follows the Forest Health Monitoring Field Methods Guide (International-Indonesia), published by USDA-Forest Service (1997). The sampling framework is based upon a triangular grid of 40 km^2 hexagons. FHM ground plots are systematically located within 1 kilometer of each hexagon center (Figure 3).

Each FHM plot consists of a series of fixed area, circular subplots tied to a cluster of four points that area spaced 36.6 m apart. A cluster design was chosen because it was proven to be cost-effective for extensive surveys. The key sampling unit for most tree measurements is the 1/60-hectare subplot. Each subplot includes a 1/750-hectare micro plot, offset from subplot center to avoid trampling. Seedlings and saplings and other vegetation are measured on the micro plot. A seedling is defined as a tree species with the height below 1.3 meter and diameter of 2.5 cm. Poles (the diameter 10-20 cm) and trees (the diameter above 20 cm) are measured on the subplot, and the annular plot was used to record the trees only.

The center of subplot 1, or point 1, is also the center of the overall plot. The other subplot centers (or points) are located as follows: point 2 is 360° and 36.6 m from point 1; point 3 is 120° and 36.6 m from point 1; and point 4 is 240° and 36.6 m from point 1. Micro plot centers are located 90° and 3.7 m from the center of each subplot (Figure 4).

All compass readings on FHM plots are taken from magnetic north, and not corrected for declination. Field data are recorded in metric units.

Ground plots are installed and marked for future remeasurement at all sample locations where any portion of 1/60-hectare subplots is forested. A plot is not established where all four subplots are obviously non-forest.

For initial plot establishment, and for future measurements where the previously established course is unsuitable, a new course to the sample plot must be scaled from aerial photography or map.

The steps for establishing a ground course to the sample plot (USDA Forest Service, 1997) are as follows:

1. Using a compass and tape, follow the azimuth and distance from the starting point to the plot center
2. Horizontal distance should be corrected for slope, but record slope distance in the field notes
3. Reference all line segments exceeding 150 m with witness trees. Mark shorter segments in areas where relocation difficulties might be expected. Forest plots are monumented by two witness trees located at least 7.3 m from the center of the lowest-numbered forested subplot (usually subplot 1). To the extent possible, witness trees should be chosen at appropriate right angle to the subplot center. Both witness trees should be base-tagged, with nails pointing toward plot center. In addition, one witness tree should be tagged at eye level, such that future crews are likely to see it as they approach the plot. By convention, the tree with the upper tag should be listed as the first of the two witness trees in the plot notes. NOTE: Witness tress should not be scribed since they are located in the annular ring surrounding subplot center.
4. At the end of course, check the map to verify that the ground location of the plot center is correct. Micro plot and subplot centers are marked with metal or wooden stakes.
5. If the 7.32 m radius around subplot 1 contains no forest, establish a turning point and proceed to the lowest-numbered subplot that does contain forest.
6. Place a permanent marker in the ground at the lowest-numbered forested subplot and reference it with two witness trees. The witness trees should be placed outside the 7.32 m subplot radius, approximately at right angles to each other with respect to the subplot center.

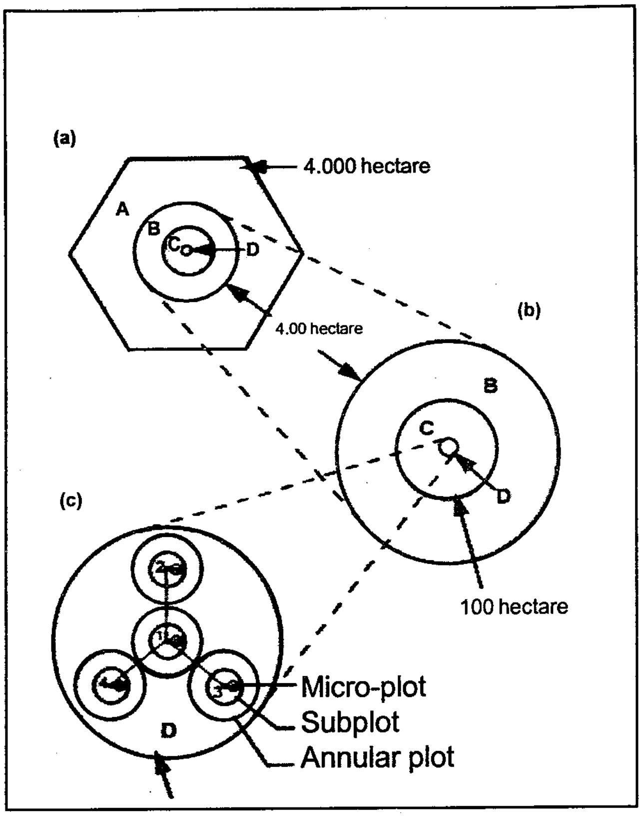

Figure 3. FHM Plot Design (USDA Forest Service, 1997)

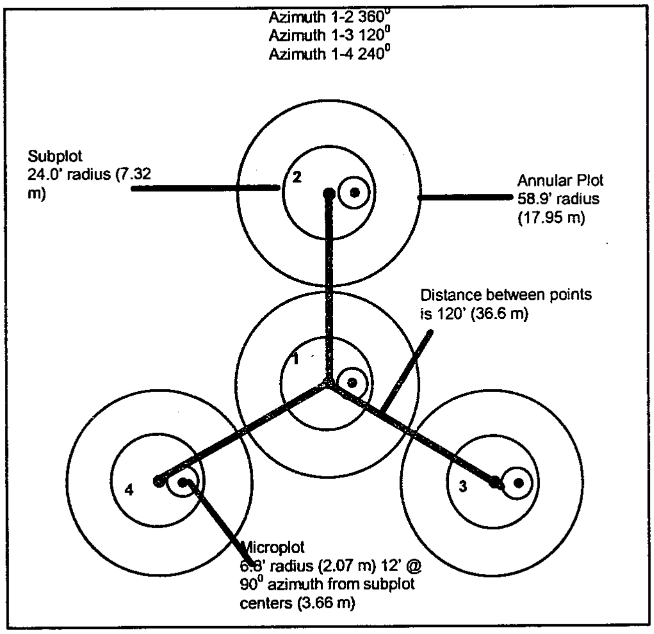

Figure 4. Detail of FHM Plot Design (USDA Forest Service, 1997)

The measurement of FHM indicators can be grouped into Forest Mensuration, Crown Condition Classification, Damage and Catastrophic Mortality Assessment, Vegetation Structure, and Soil Measurement and Sampling. Data collection and measurement of each FHM indicator is described in detail in Forest Health Monitoring Field Methods Guide (International – Indonesia) issued by USDA-Forest Service, 1997, but in general, can be highlighted as follows.

3.1. Forest Mensuration

Estimation of growth (stands dynamics) and measurement of trees and stands (stand structure) are important Forest Health Monitoring (FHM) program objectives. Stand dynamics includes three elements that are important *indicators* of forest health: (1) rates of regeneration, (2) survivor growth, and (3) mortality. These data are obtained by remeasuring trees on permanent plots through a series of successive inventories (Husch *et.al.*, 1972). An additional objective of Forest Mensuration measurements is providing a basic plot framework upon which to conduct field activities associated with other forest health indicators not traditionally associated with other forest mensuration (i.e., vegetation structure, lichen communities and PAR). As such, these indicators can be correlated with stand dynamics and stand structure. The data can be recorded in electronic tally sheet (Portable Data Recorder = PDR). The PDR program is provided by the US – FHM. In case, the PDR is not available, the data can be recorded in formatted tally sheet.

The level data can be classified into Plot level, plot identification data, condition classification, site tree data, boundary data, plot description, understory vegetation, microplot seedlings, microplot sapling, and subplot tree data. For detailed information, see the Forest Health Monitoring Field Guide (International-Indonesia), 1997 and Tally Sheet (Appendices 1,2,3).

3.2. Crown Condition Classification

A multitude of abiotic and biotic influences shape forest trees. Tree, seedling, sapling, and pole vigor and growth can be determined by a variety of physiological and external influences, such as age, availability of light, water, and nutrient. Forest health might be reflected by crown condition of stand structure. Crown evaluation measurements are listed in the order of data collection on each tree:

(1) Crown diameter wide and 90 degrees.
(2) Live crown ratio,
(3) Crown density,
(4) Crown dieback, and
(5) Foliage transparency.

All crown variables for seedlings, saplings, and trees are evaluated during plot establishment (Mt1) and completely reevaluated when the plot remeasurement (Mt3) occurs. Each crown condition is coded for facilitating in transferring the data to Portable Data Recorder program. The procedures of evaluation is described in detail in *Forest Health Monitoring Field Guide (International - Indonesia),* 1997, issued by the USDA-Forest Service and Tally Sheet (Appendices 1,2,3).

3.3. Damage Assesment

Damage caused by pathogens, insects, air pollution and other natural and man-made activities can affect the growth and development of trees. Damage caused by any of these agents, either singly or in combination, can significantly affect forest health. Identifying the signs and symptoms of damage provides valuable information concerning the forest's conditions. For Forest Health Monitoring (FHM), damage signs and symptoms are recorded if, by definition, the damage could kill the tree or affect the long-term survival of the tree (USDA-FS, 1997).

The production indicator concerns very much the tree damage. It will affect the wood production in terms of quantity and quality.

Measurement of damage indicator involves damage location, type of damage and damage severity. Each indicator is evaluated, coded, classified and analyzed to find a conclusive recommendation.

The procedures of evaluation is described in detail in *Forest Health Monitoring Field Guide (International - Indonesia),* 1997, issued by the USDA-Forest Service and Tally Sheet (Appendices 1,2,3).

3.4. Vegetation Structure

The vegetation structure indicator provides information on the species composition, relative amounts of cover, and spatial distribution of vascular plants. Further, it quantifies habitat structure, which strongly influences wildlife diversity (DeGraaf and Rudis, 1983). Plants are one of many taxa that should be measured in order to fully assess forest biodiversity on a regional scale. Vegetation structure complements other indicators, particularly PAR, Wildlife habitat, crown condition, growth, regeneration, mortality and species diversity (USDA-Forest Service, 1997).

The procedures of evaluation is described in detail in *Forest Health Monitoring Field Guide (International - Indonesia),* 1997, issued by the USDA-Forest Service and Tally Sheet (Appendices 1,2,3).

3.5. Soil Measurement and Sampling

The role of soil in forest health is protecting soil quality, like protecting air and water quality, should be a fundamental goal of national environment policy (The National Research Council, 1993). The three major roles played by soil in terrestrial ecosystem are productivity and bio-diversity, environmental buffer and hydrologic function. Soils are mainly responsible for plant growth. Within a given climatic zone, soils largely determine the nature, productivity, and spatial distribution of plant communities.

Soil properties largely determine whether infiltrates or runs off. By regulating water movement on the landscape, soils have pronounced influence on regional and local hydrology. Soils are extremely reactive, both chemically and biologically. As a result, they have the valuable capacity to degrade, decompose or immobilize substances. Soil is major reservoir of carbon and nitrogen in the terrestrial ecosystem.

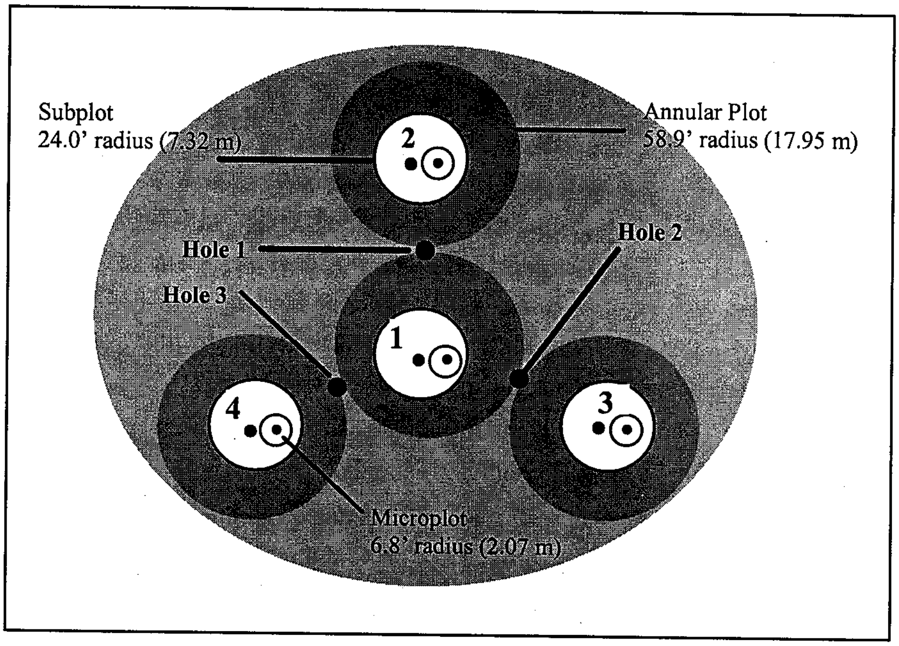

Figure 5. Location of soil sampling holes

The plot system of soil measurement and sampling is shown in Figures 5 and 6. The procedure of soil measurement and sampling is described in detail in Forest Health Monitoring Field Methods Guide (International-Indonesia), 1997, page 8-1 to 8-9.

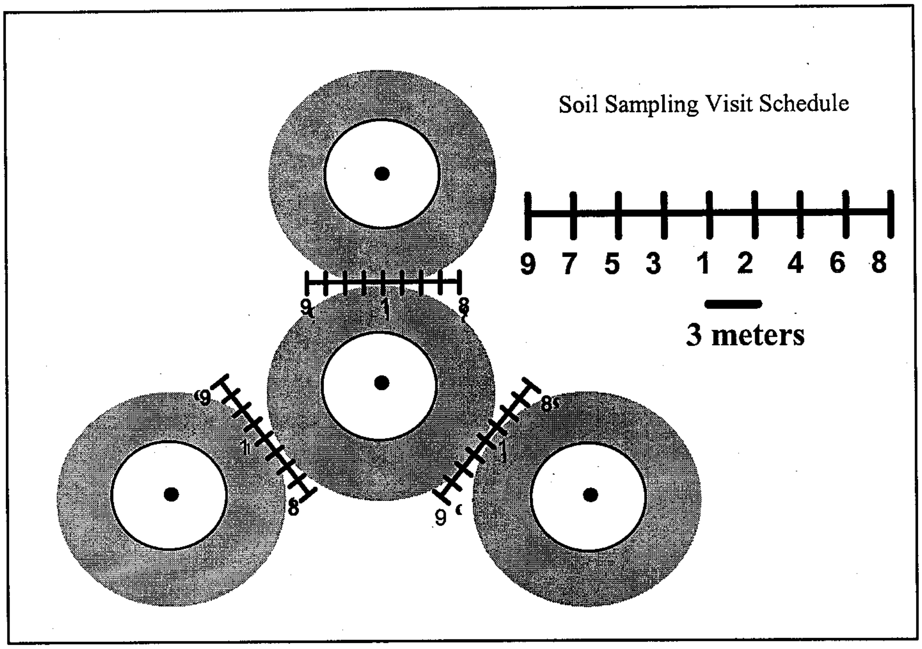

Figure 6. Soil sampling visit schedule

IV. DETECTION MONITORING PLOT

4.1. Background

In 1989, the Government of Indonesia initiated the National Forest Inventory (NFI) Project, which was technically assisted by the FAO. The objectives of this project were providing information on the location and extent of the main forest types, estimating the standing volumes and growth, and assessing the status, change of the forest. The project includes forest resources assessment (FRA), forest resources monitoring (FRM), digital image analysis systems (DIAS) and geographic information systems (GIS). To quantify the standing stock as the forest changes overtime, the NFI applies the remote sensing techniques and the systematic field sampling method. The field samples are cluster plot consisting of 3 by 3-square plots of 100 meters in size and 500 meters apart. Of there, 8 at the edges and 1 at the center are treated as temporary and hidden permanent sample plots, respectively (Figure 7).

However, the systems do not concern biodiversity and such indicators as suggested by ITTO Guidelines, 1991, for well-managed tropical ecosystems. Those indicators are resource security, the continuity of timber production, the conservation of flora and fauna, an acceptable level of environmental impact and socio-economic benefit.

The indicators of well-managed forest ecosystem must be equally defined by the environmental, economic and social attributes.

Forest Health Monitoring (FHM) was first developed in the U.S. in 1991. The FHM is an ecological approach to evaluate forest ecosystems for condition, changes, trends, causal agents and mechanisms, monitor the condition and changes in forest ecosystems. It is a ground-based estimate of the condition and trends in the forests, by monitoring the proportions of forest population that are in poor, sub-nominal, nominal or optimal condition of each indicator.

One group of criteria to be addressed in INDO-FHM is environmental criteria, which will address biodiversity composition, abundance, habitat suitability and ecosystem processes (growth, regeneration, mortality, stand structure) and productivity. The environmental indicator tested in the demonstration plot was biodiversity. These indicators should be tested in NFI plot system to address the forest sustainability in terms of biodiversity to assess the healthy of forest ecosystem.

The objective of this study was to assess the biodiversity indicator used in FHM within NFI plot systems.

4.2. Plot Establishment Procedures

FHM cluster plots number 9 and 8 were established and overlaid to NFI plots (number 503209620 and 503209600), respectively. Those plots are located at PT Sumpol Timber, South Kalimantan. FHM cluster plot number 4 was established and overlaid on NFI plot number 573209760. FHM cluster plot number 4 is located at PT Asia Log, Jambi. The NFI plot system is shown in Figure 7. The overlay of FHM plot on NFI plot system is shown in Figure 8. The FHM plot model and data recording followed the Forest Health Monitoring Field Methods Guide (International-Indonesia) issued by the EPA (1997).

The FHM center plot on plot 1 was located in the crossing between two diagonal lines of the NFI Permanent Sample Plot (PSP). In this case, the position of FHM plot number 2 will be partly (5 m) outside of NFI Permanent Sampling Plot (See Figure 8).

FHM plot establishment (Figure 4) and tree data recording system followed the Forest Health Monitoring Field Method Guides (International- Indonesia) issued by EPA (1997). The trees with diameter over 10 cm were measured and recorded. The data of NFI was taken from the inventory results conducted by the Agency of Forest and Estate Crops Planning, Ministry of Forestry and Estate Crops (MOFEC) in 1998. The NFI data was recorded 3 months before FHM plots establishment.

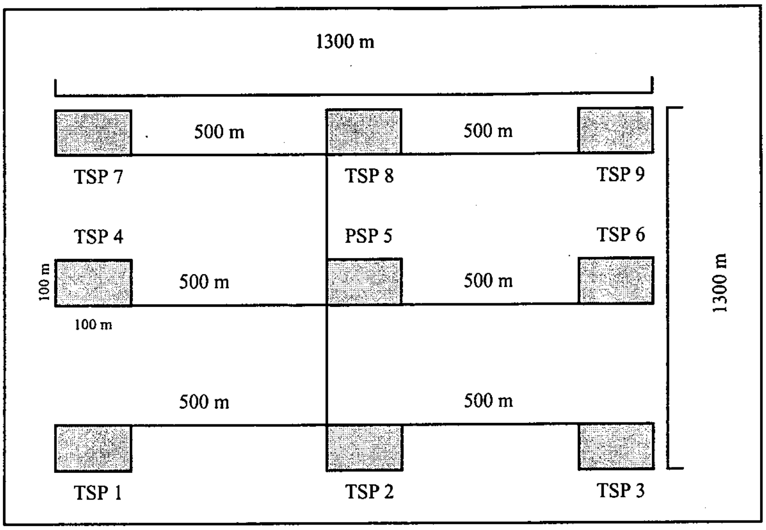

Figure 7. National Forest Inventory Plot System.
TSP: Temporary Sampling Plot, PSP: Permanent Sampling Plot (Hidden Plot)

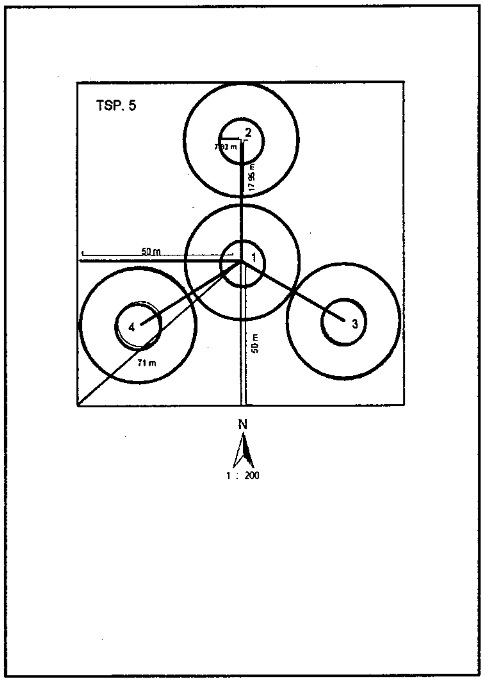

Figure 8. The Overlaid FHM Plot on NFI Permanent Sampling Plot (PSP).

V. FHM PLOT LOCATION

5.1. Pulau Laut

The FHM cluster plot in Pulau Laut is located in Protection Forest (Buffer-zone: plots number 1 and 7, and Biodiversity Conservation Area: plot number 2), in Plantation Forest (Plot number 3), and Seed Production Area (Plots number 4, 5 and 6). The total plot number is 7 cluster plots representing different types of forest function. The detail FHM cluster plots are shown in Figure 9 – 15.

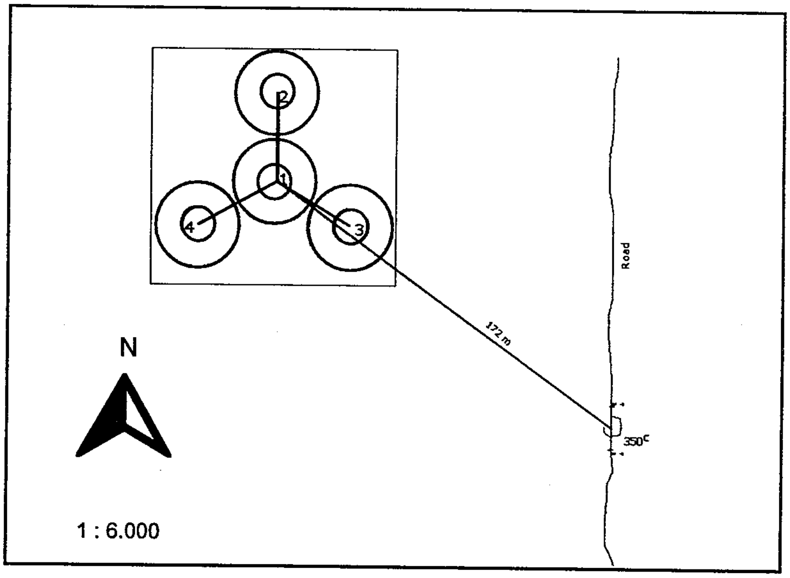

Figure 9. Location of FHM Cluster Plot 2 at Biodiversity Conservation Area, Pulau Laut, South Kalimantan

FHM cluster plot 2 can be reached through the border of Biodiversity Conservation Area, Block number 2, at horizontal distance of 172 m from main road, and azimuth 350°; then we will find the center plot. The area is stony / rocky. The distance from center plot 1 to the top hill is 500 m. The slope from the starting point is steep, with the slope of >45%. The reference point is a big stone in 1.5 m in diameter, located in between at point 15 to 16 km of the logging road. The vegetation is dominated by *Shorea polyandra* and *Dipterocarpus caudiferus*.

The FHM cluster plot number 3 can be reached by car using the main road. The reference point to the center plot 1 is a border block number B/HP/ 114 made of cement. The horizontal distance from reference point to the plot center is 74.2 m, with azimuth 104°. The cluster plot is located in *Shorea polyandra* plantation, planted in 1976. The area is flat, with the slope 5 – 35 % The aspect from center plot 1 to plot 4 is 360^0, with the slope 5%. The plot is weavy, no rock, no stone, less under growth and less natural regeneration.

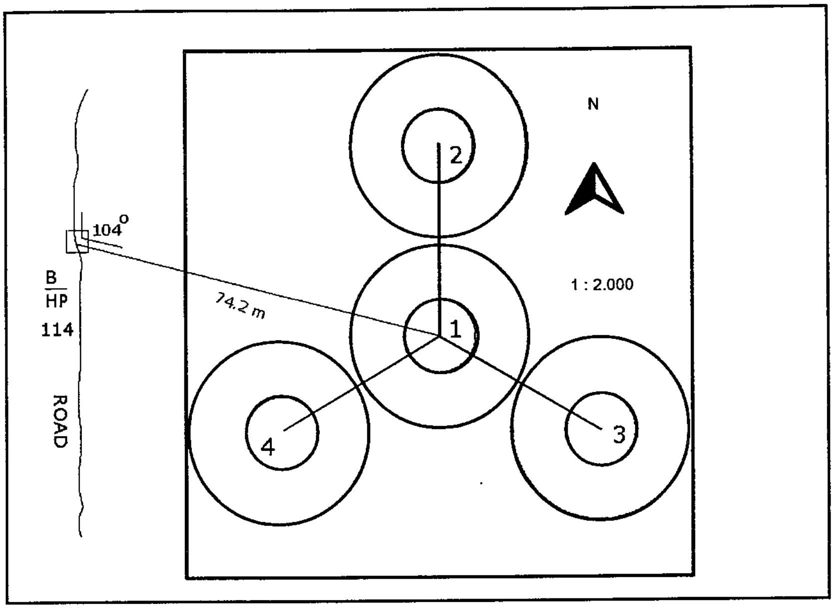

Figure 10. Location of FHM Cluster Plot 3 At *Shorea polyandra* Plantation, Pulau Laut, South Kalimantan

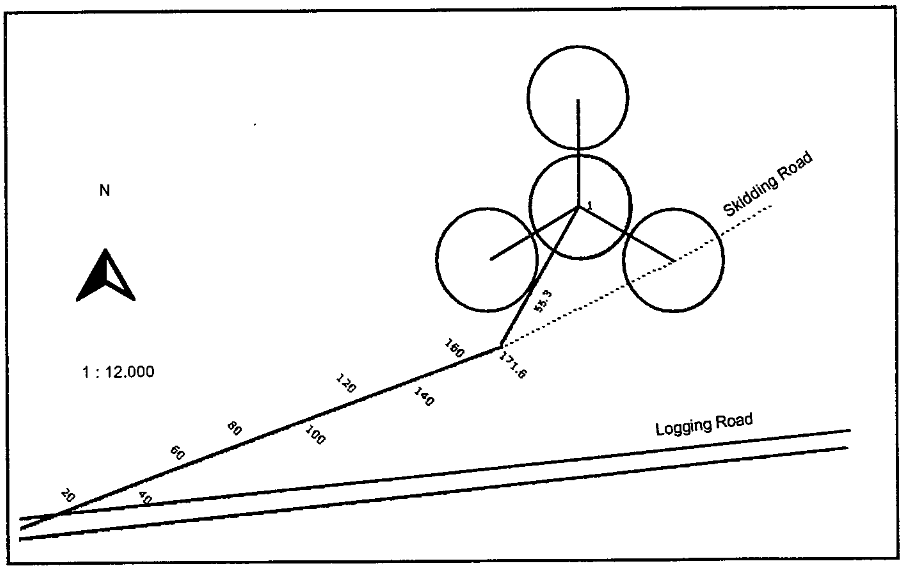

Figure 11. Location of FHM Cluster Plot 1 at Buffer Zone, PT. INHUTANI II, Pulau Laut - South Kalimantan

FHM cluster plot 1 can be reached through the "Minister road-tracking", at horizontal distance of 171.6 m, and azimuth 60^0, then we will find the witness tree of *Shorea polyandra*. The center plot will be reached at horizontal distance of 55.3 m, and azimuth of 315^0.

Cluster plots number 4, 5 and 6 (Figure 12) are located in seed production area. Cluster plot number 4 was located in a seed production area, and can be reached by car through the main road. The reference point of cluster plot 4 is a point of 6 km. The horizontal distance from reference point to the plot center 1 is 120 m, with azimuth 42^0. The area is flat, with a slope of 10%, no stone, aspect 240^0. The aspect from center plot 1 to plot 2 is 240^0, and with a slope of 0%. The area is dominated by *Dipterocarpus caudiferus* and other mixed species.

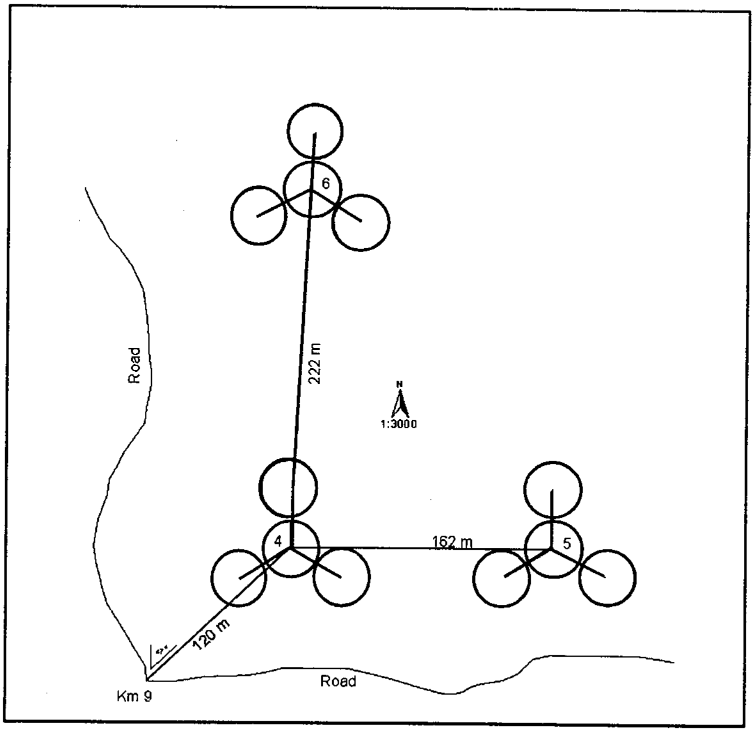

Figure 12. Location of FHM Cluster plot 4, 5, 6 at Seed Production Area, PT. INHUTANI II, Pulau Laut – South Kalimantan

FHM cluster plot number 5 (Figure 13) is located at 90^0 from center plot 1, cluster plot 4, at horizontal distance 142 m to the center plot 1. The area is originally a seed production area, dominated by *Dipterocarpus caudiferus*. The slope of the area is 10% at aspect 130^0 from the center plot 1, no stone, weavy.

FHM cluster plot number 6 (Figure 14) is located at a horizontal distance 222 m from the center plot number 1 of cluster plot number 4, with azimuth 0^0. The area is undulated, transected by a small river of 5 m wide in between cluster plots 1 and 2. The area is dominated by *Dipterocarpus caudiferus* and other Dipterocarps species. The aspect of the area is 180^0 with a slope of 25%.

Cluster plot number 7 (Figure 15) is located at a buffer zone (Protection Forest) at 148 m, with azimuth 200^0 from the center plot 1 of cluster plot 1, then turn 270^0 at 34.2 m to reach the center plot 1 of cluster plot 7. The area is dominated by *Shorea polyandra* in big diameter. The topography of the area is dissected, stony in some at plot 4. Plot number 3 is closed to top-hill. Regeneration is dominated by the *Shorea polyandra*. The slope of the area is 45%, at aspect 300^0.

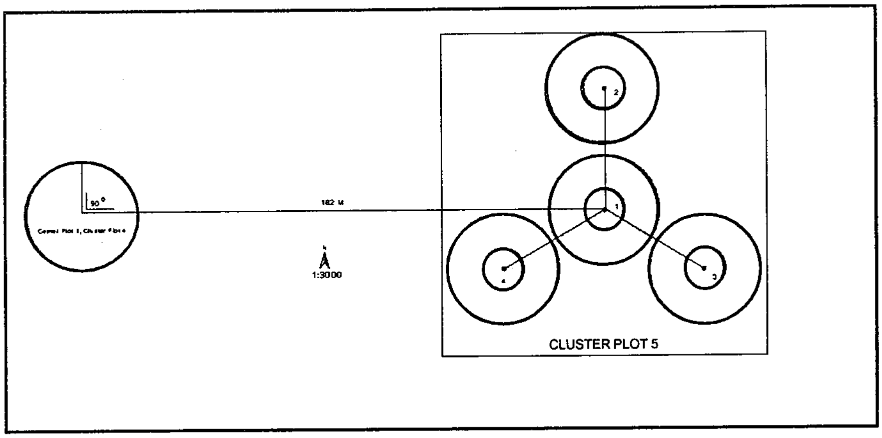

Figure 13. Location of FHM Cluster plot 5 at Seed Production Area, PT. INHUTANI II, Pulau Laut, South Kalimantan

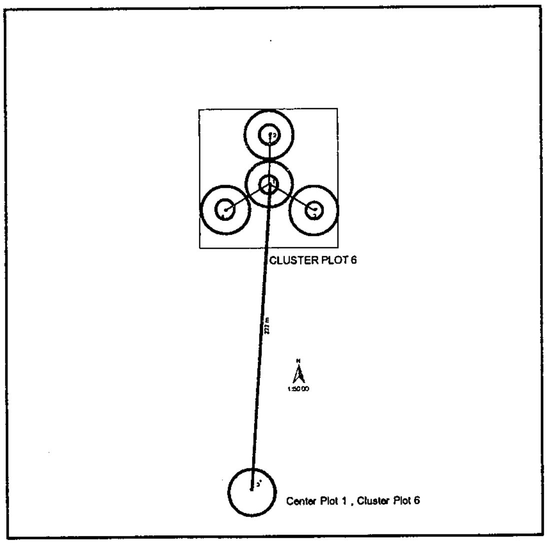

Figure 14. Location of FHM Cluster plot 6 at Seed Production Area, PT. INHUTANI II Pulau Laut – South Kalimantan.

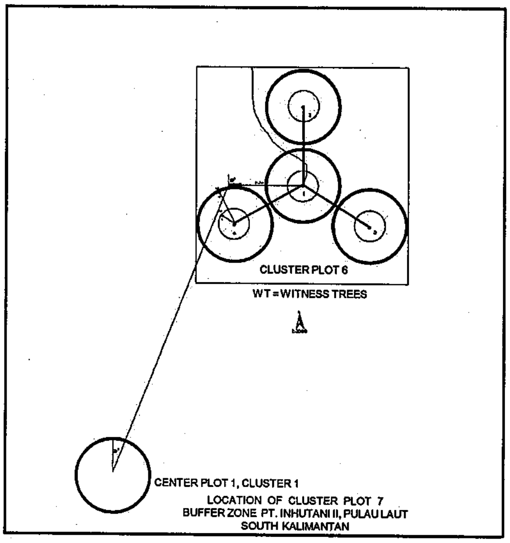

Figure 15. Location of FHM Cluster plot 7 at Buffer Zone, PT. INHUTANI II, Pulau Laut – South Kalimantan

5.2. Jambi

Plot Location in Jambi is shown in Figures 16, 17, 18, 19 and 20. The cluster plots condition is as follows.

Cluster Plot Number 1

Cluster plot number 1, dominated by Dipterocarps, was logged in 1995. This cluster plot is located at a horizontal distance ± 323.1 m from the witness trees (Palm tree), with azimuth 203° to the plot center 1. The witness tree is located at Km 29 of the logging road. The area is flat with a slope of 5% and aspect of 90°. See Figure 16.

Cluster Plot Number 2

The area, dominated by Dipterocarps, was logged in 1995. The horizontal distance to the plot center from the reference point was ± 620.2 m, with azimuth 20° from the witness tree (Palm tree). The slope of the area is 5% in average at the aspect of 80°. At the distance of 100 m from the center plot 1, we found a river 5 m wide. See Figure 17.

Cluster Plot Number 3

Cluster plot number 3 is located at a seed production area that is also used for Genetic Resources Area. The plot center is located at a horizontal distance of 160.3 m from the boundary pole of Km 29, with azimuth of 46°. The area is flat, with the slope of 7% in average, at aspect of 46°. See Figure 18.

Cluster Plot Number 4

Cluster plot number 4 is located at a horizontal distance 1,795 m from the reference point (SPAS station), and at azimuth of 45⁰. The FHM cluster plot was also overlaid on NFI Permanent Sampling Plot. The area is dominated by Dipterocarps species, and belongs to a virgin forest. The slope of the area is 5% in average on the aspect of 150⁰. SPAS (Monitoring Station of River-Current) were used as reference point. See Figure 19.

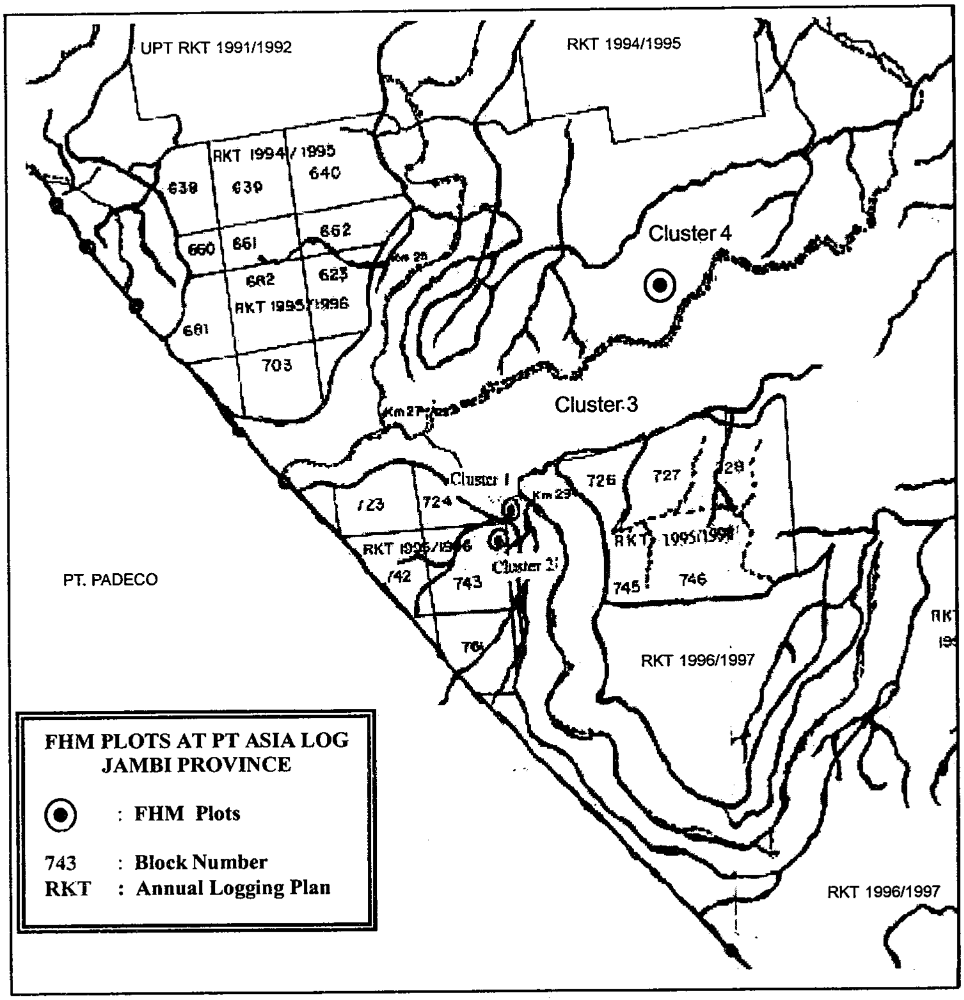

Figure 16. FHM Plots Location in PT Asia Log

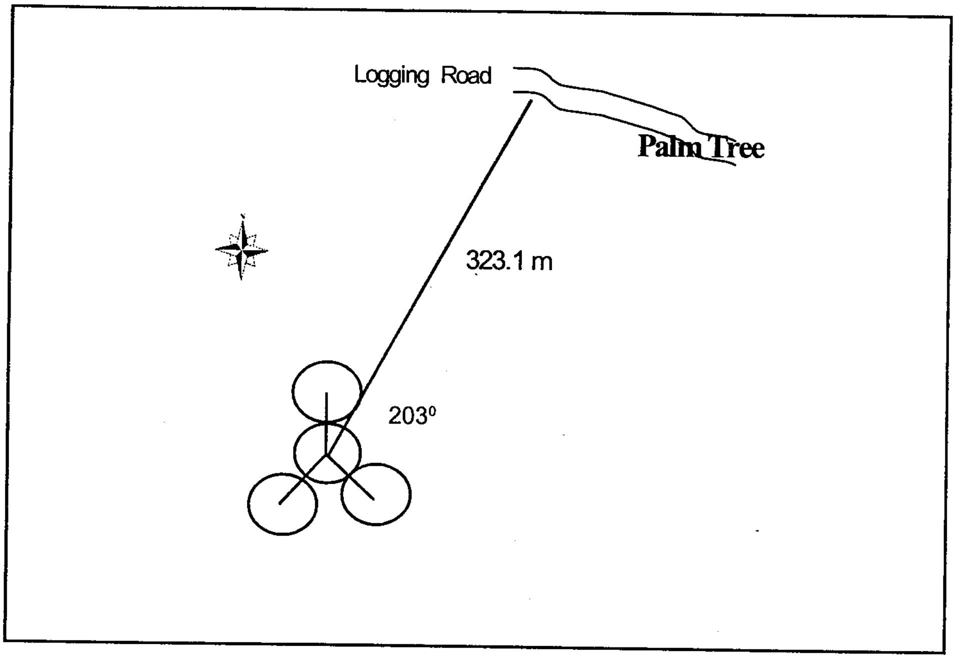

Figure 17. Location of FHM Cluster Plot 1 at PT Asia Log, Jambi

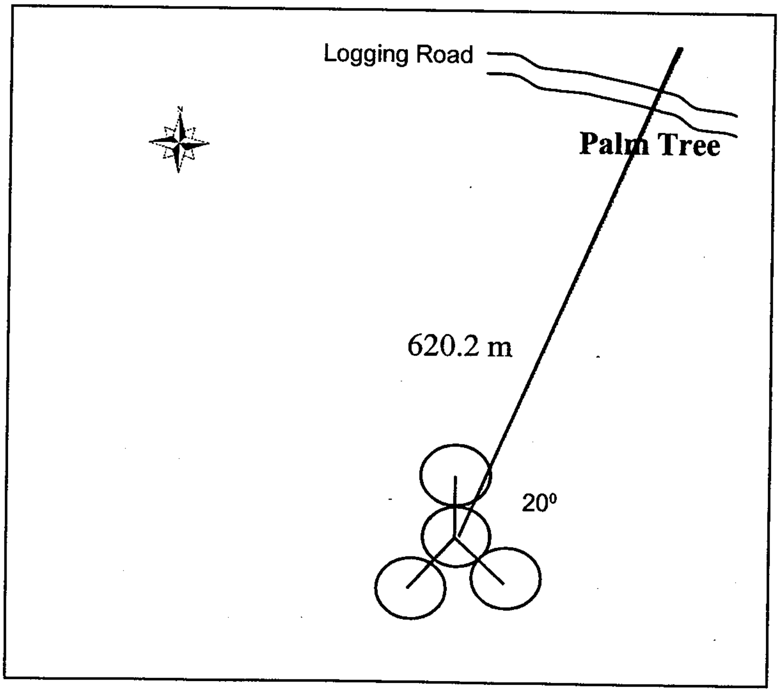

Figure 18. Location of FHM Cluster Plot 2 at PT Asia Log Jambi

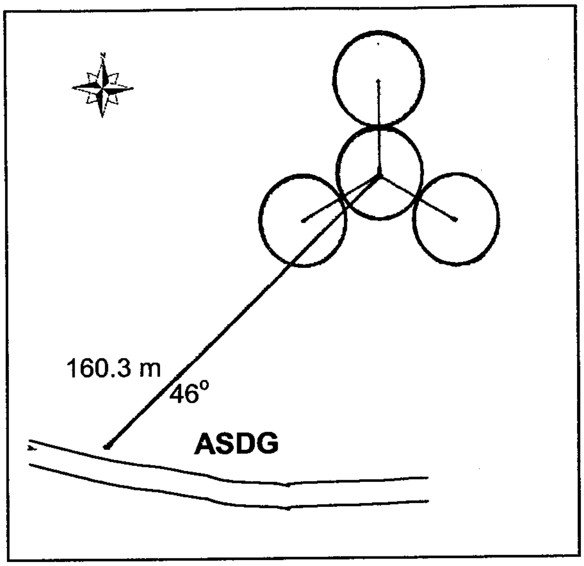

Figure 19. Location of FHM Cluster plot 3 at PT Asia Log, Jambi

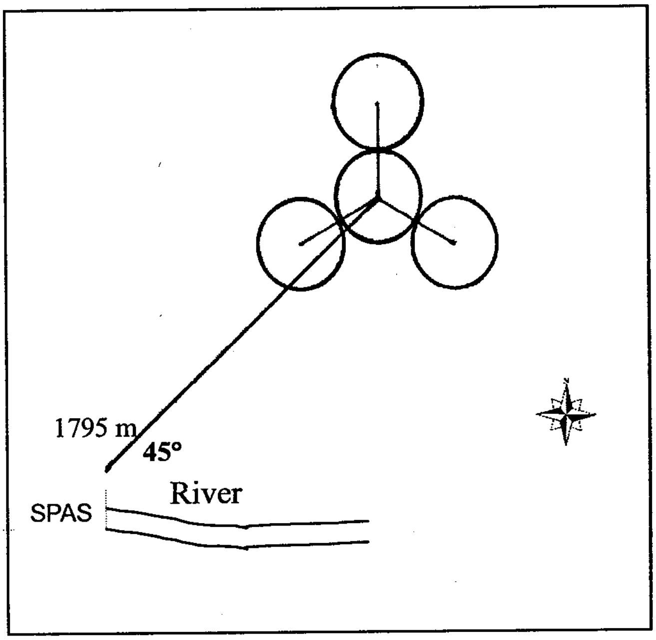

Figure 20. Location of FHM Cluster Plot 4 at PT Asia Log, Jambi

5.3. Detection Monitoring Plot

The detection monitoring plots were established at PT Asia Log, Jambi and PT Sumpol, South Kalimantan (Figures 21 and 22). The FHM plots were overlaid on

Permanent Sample Plot of National Forest Inventory plot system. The Detection Monitoring Plot at PT Asia Log is also known as FHM cluster plot number 4.

Cluster plot number 4 is located at the horizontal distance 1795 m from the reference point (SPAS station), and at azimuth of 45°. The FHM cluster plot was also overlaid on NFI Permanent Sampling Plot. The area is dominated by Dipterocarps species, and belongs to a virgin forest. The slope of the area is 5% in average on the aspect of 150°. SPAS (Monitoring Station of River-Current) were used as reference point.

The NFI cluster was measured in 1993 and remeasurement was done in 1998, or every 5 years. Detection Monitoring Plot in PT Sumpol is shown in Figure 23, while the vegetation maps of the area were obtained by the digital interpretation of satellite images from Landsat-TM Band 5-4-2, Path/Row 117/062 1998, purchased from LAPAN (National Aerospace and Aviation Agency), see Figures 23 , 24 and 25.

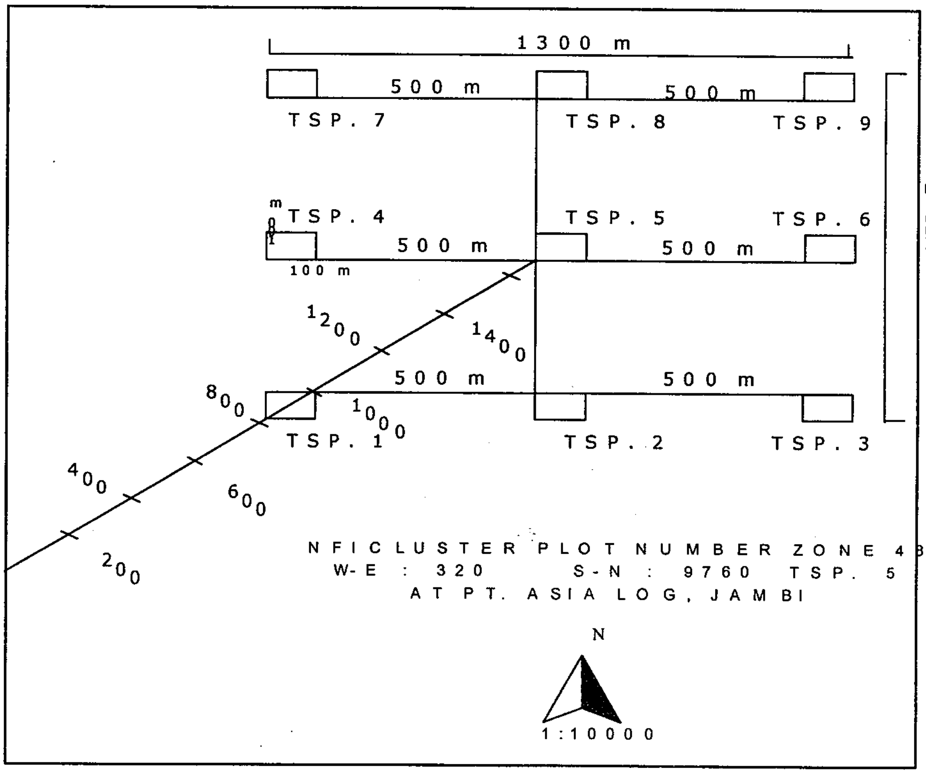

Figure 21. FHM Cluster Plot Number 4 Overlaid on NFI Cluster Plot Number Zone 48 W-E : 320 S-N : 9760, TSP 5 at PT Asia Log, Jambi

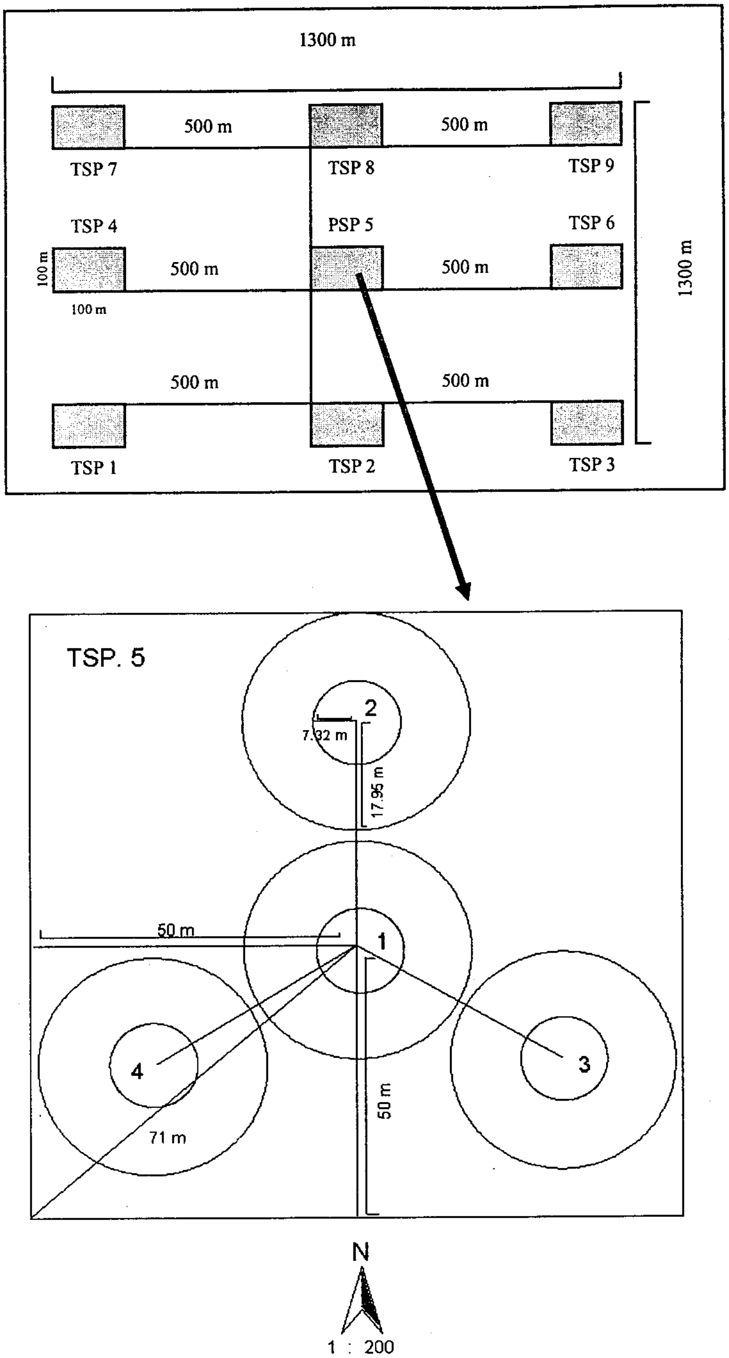

Figure 22. Overlay position of FHM plot on NFI plot system in PT Asia Log, Jambi and PT Sumpol, South Kalimantan

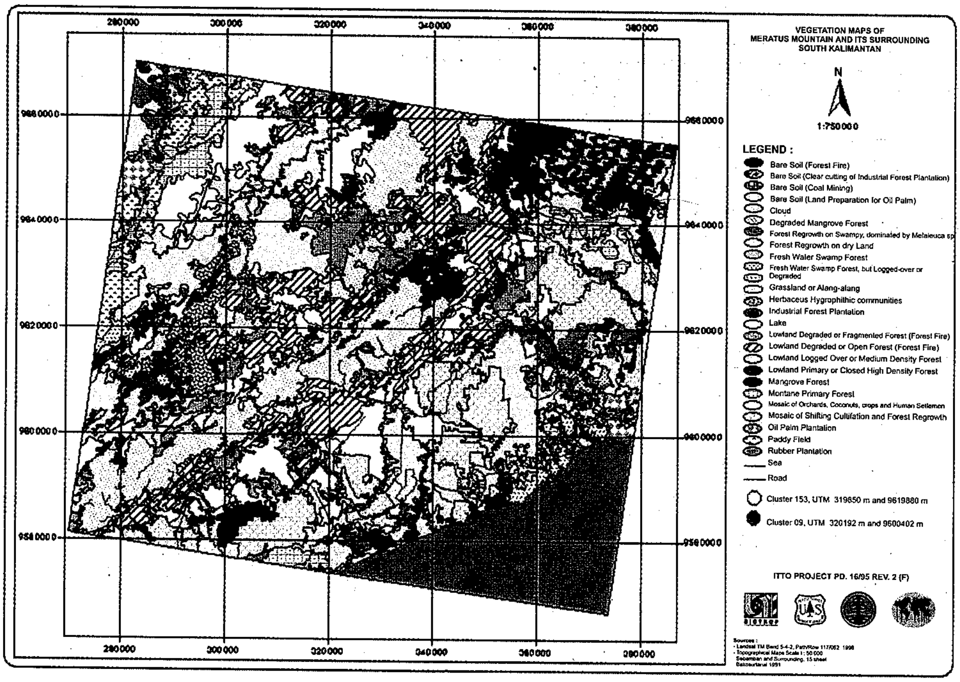

Figure 23. Vegetation Map of Meratus Mountain and Its Surrounding South Kalimantan

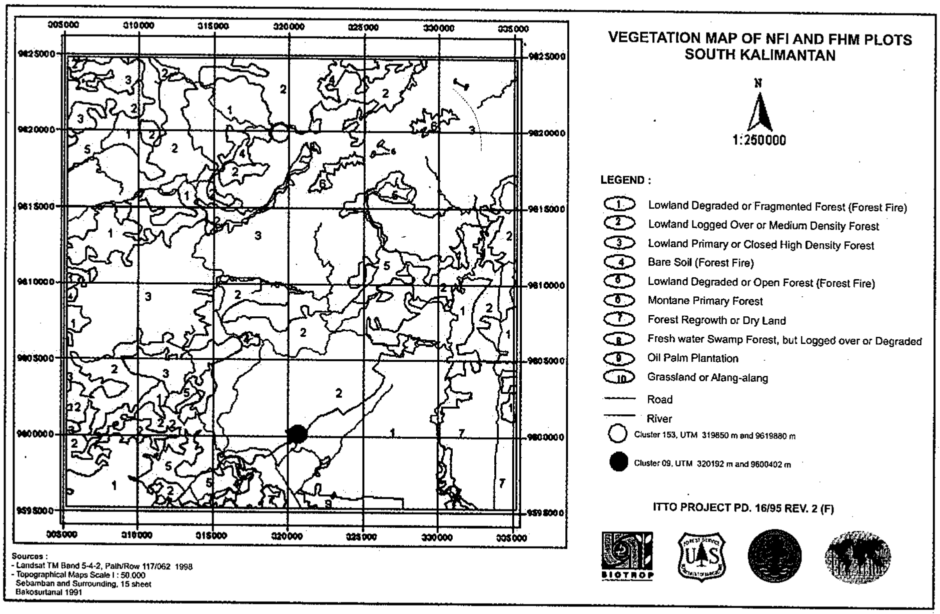

Figure 24. Vegetation Map of NFI and FHM Plots, South Kalimantan

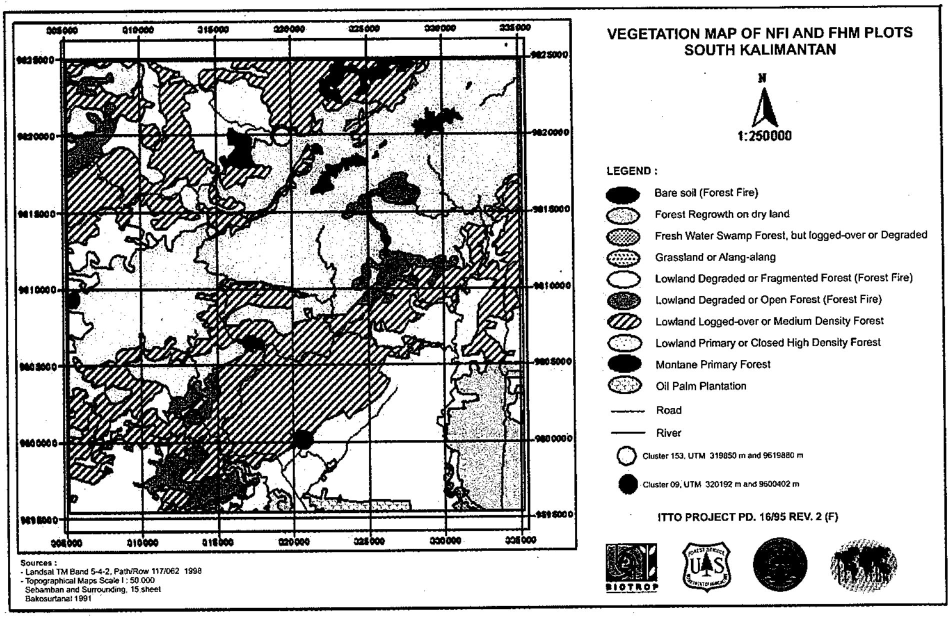

Figure 25. Vegetation Map of NFI and FHM Plots South Kalimantan

5.4. Training Plot

The training plots were established in PT. Asialog, Jambi; PT INHUTANI II, Pulau Laut; and, Gede Pangrango National Park, Cibodas. Besides for the demonstration plots, Cluster-plot No. 1/ Pulau Laut and Cluster-plot No. 3 / Jambi were designed also for the training purposes. Field practice of Introductory Training of FHM was held in 1995 in Cluster-plot No. 3 / Jambi while Cluster-plot No. 1 / Pulau Laut was used for the field practice of Training Workshop on FHM in 1996.

Training plot in Gede Pangrango National park was established in 1999 and has been used for field practice of Training Courses on FHM for ASEAN Scientist in 1999 and 2000. Center-plot No. 2 of this training plot was located closed to Cibodas Botanical Garden border point No. II B with the horizontal distance of 25.45 m and the azimuth of 2100 (Figure 26).

Establishment of the FHM training plots was aimed to introduce the FHM methodology to the concerned stakeholders, and to provide the appropriate training plot to train both national and regional scientists and crews in data collection and parameter measurement. The training plots will be used for the training course and research station on Forest Health Monitoring program for the scientists coming from Southeast Asian countries.

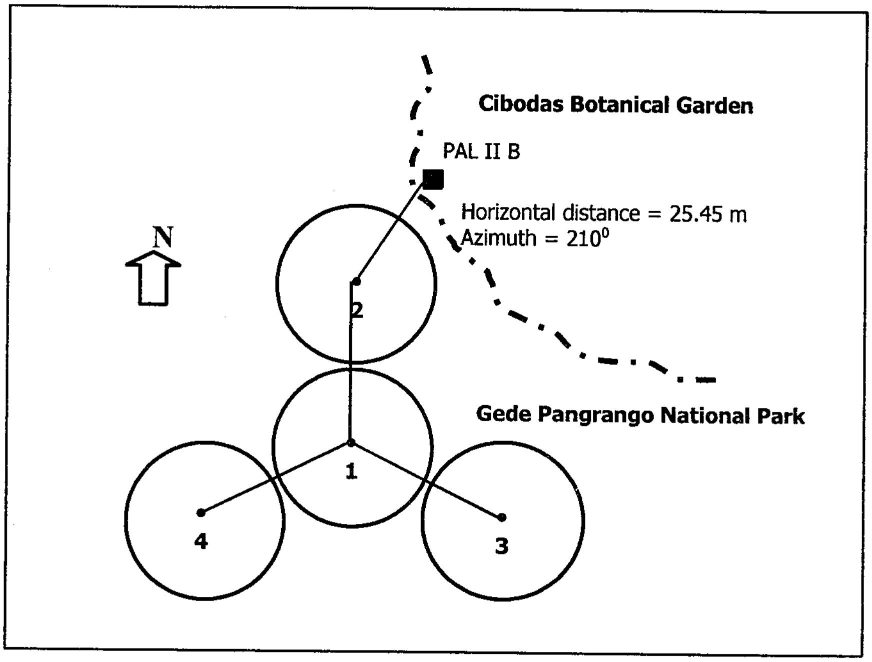

Figure 26. Location of FHM Training Plot at Gede Pangrango National Park, Cibodas

ACKNOWLEDGEMENT

This Technical Report No. 1 on Plot Establishment has been prepared to fulfill Objective 1 Point 2.2 of the Workplan of ITTO Project PD 16/95 Rev. 2 (F): Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest.

The authors would like to thank ITTO, the Ministry of Forestry (GOI), PT. SUMPOL, PT. INHUTANI II and PT. Asialog Concession Holders for their support. Appreciation also goes to the Project Steering Committee members for their suggestions.

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Appendix 1: FOREST HEALTH MONITORING SOIL MEASUREMENTS

Country ____________ Hex Number____________________.

Date______________ Crew Member (s)_________________.

Start Time___________ Stop Time__________.

1. Organic Layer Thickness						% Cover (r = 2m)	
	N	E	S	W	Average	Duff	Soil
Sampling Point 1 (cm)	____	____	____	____	____	____	____
Sampling Point 2 (cm)	____	____	____	____	____	____	____
Sampling Point 3 (cm)	____	____	____	____	____	____	____
			Plot Average		____	____	____

2. A. Horizon Thickness					
	N	E	S	W	Average
Sampling Point 1 (cm)	____	____	____	____	____
Sampling Point 2 (cm)	____	____	____	____	____
Sampling Point 3 (cm)	____	____	____	____	____
			Plot Average		

3. Depth to Subsoil					
	N	E	S	W	Average
Sampling Point 1 (cm)	____	____	____	____	____
Sampling Point 2 (cm)	____	____	____	____	____
Sampling Point 3 (cm)	____	____	____	____	____
			Plot Average		____

4. Field Texture Determination (check appropriate texture class for each sampled layer)			
Point 1 :			
A. Horizon	Loamy	Clayey	Sandy
Underlying 10 cm layer	Loamy	Clayey	Sandy
Point 2 :			
A. Horizon	Loamy	Clayey	Sandy
Underlying 10 cm layer	Loamy	Clayey	Sandy
Point 3 :			
A. Horizon	Loamy	Clayey	Sandy
Underlying 10 cm layer	Loamy	Clayey	Sandy

Appendix 2

Field Data Sheet 1
Forest Health Monitoring Soil Measurements

State ________________ Hex Number ________________

Date ________________ Crew Ldr. ________________

---

1. Organic Layer Thickness (Mean of 4 Measurements) Measured only at Sampling Point 1 ______ cm

---

2. A. Horizon Thickness

Sampling Point 1 (Mean of 4 Measurements) ______ cm

Sampling Point 2 (Mean of 4 Measurements) ______ cm

Sampling Point 3 (Mean of 4 Measurements) ______ cm

Total ______ cm

Plot Average : Total/ 3 ______ cm

---

3. Depth to Subsoil

Sampling Point 1 (Mean of 4 Measurements) ______ cm

Sampling Point 2 (Mean of 4 Measurements) ______ cm

Sampling Point 3 (Mean of 4 Measurements) ______ cm

Total ______ cm

Plot Average : Total/ 3 ______ cm

4. Field texture determination (check appropriate texture class for each sampled layer)

Point 1

0 to 10 cm layer Loamy________ Clayey_______ Sandy______.

10 to 20 cm layer Loamy________ Clayey_______ Sandy______.

Point 2

0 to 10 cm layer Loamy________ Clayey_______ Sandy______.

10 to 20 cm layer Loamy________ Clayey_______ Sandy______.

Point 3

0 to 10 cm layer Loamy________ Clayey_______ Sandy______.

10 to 20 cm layer Loamy________ Clayey_______ Sandy______.

Appendix 3

FOREST HEALTH MONITORING
TO MONITOR THE SUSTAINABILITY
OF INDONESIAN TROPICAL RAIN FOREST

EROSION SOIL MEASUREMENTS DATA SHEET

Cluster ____________________

Date ______________________

Start Time ____________________

Stop Time ____________________

Crew Member(s) ____________________

____

____

Sub-plot	Bare Soil %	Litter %	Litter Depth	Litter Decomp.	Slope Length (m)
1					
2					
3					
4					

DATA COLLECTION, ANALYSIS AND MANAGEMENT

Technical Report No. 2

Erianto Indra Putra
Purnadjaya

ABSTRACT

INDO-FHM data have been collected using tally sheets or portable data recorder. Tally sheets were used for recording INDO-FHM field data from the first measurement in 1996 and re-measurements in 1997, 1998, 1999 and 2000, and they have been stored safely up till now. Data have also been managed in some reports done in 1997, 1998, 1999 and 2000. Starting October 1997, the INDO-FHM Database was being used to manage all of INDO-FHM field data. Some rectification and updating on INDO-FHM Database are continuously being done to improve its capability.

Key words: *Data recorder, INDO-FHM Database*

I. INTRODUCTION

Data is commonly defined as fact findings or observations, typically about physical, biological phenomena or business transactions. More specifically, data are results of observations of the attributes (the characteristics) of entities (such as people, places, things and events). These measurements are usually represented by symbols such as numbers and words, or by codes composed of a combination between numerical, alphabetical, and other characters (Deans and Kane, 1992).

Collecting data is a very important role in forest mensuration activity, especially if that is a repeating activity. Mensuration activity in Forest Health Monitoring to Monitor the Indonesian Tropical rain Forest (INDO-FHM) is generally executed periodically in time, in order to reconcile all changes that have occurred since the previous inventory. Forest mensuration activities of FHM fall into three general categories : Measurement Type 0 (Mt0), Measurement Type 1 (Mt1) and Measurement Type 3 (Mt3). Plots are categorized as such on the basis of their current and previous forest status. In general, Mt0 protocols are used for non-forest and inaccessible plots, Mt1 protocols are used for the initial installation of forested plots, and Mt3 protocols are used to remeasure previously installed forested plots. Specific guidelines on assignment of measurement type are as follows :

(1) Mt0 : The plot is currently non-forest or inaccessible at the previous inventory; and the plot is being visited for the first time, or the plot was non-forest or inaccessible at the previous inventory,

(2) Mt1 : The plot is currently forested and accessible; and the plot is being visited for the first time, or the plot was non-forest or inaccessible at the previous inventory, and

(3) Mt3 : The plot was forested and accessible at the previous inventory, regardless of whether the plot is currently accessible or forested.

The specific objectives of the INDO-FHM are: (1) Evaluation of the significance of the selected indicators in relation to the question of assessment under the conditions existing in tropical rain forests; (2) Establishment of the FHM plot system and related appropriate indicators within the existing Indonesian National Forest Inventory plots to address forest sustainability, including species biodiversity, and effort for the improvement of socio-economic conditions of the local communities; (3) Use of the FHM plots in tropical rain forests as demonstration site for future reference on the establishment of the FHM program in Southeast Asian Tropical Rain Forests; (4) Technology transfer on linking remote sensing technique, including videography, to ground base of NFI plots, FHM plots, and Ecological Classification system; and (5) Technology transfer on the use of FHM methods and existing software for the analysis of productivity data collected from existing NFI plots. The output of this specific objective is Report on a system to establish a formula to estimate productivity based on stand population.

II. DATA COLLECTION

There are twelve group of field data (PDR menus) collecting from INDO-FHM plots : plot level note, plot identification, condition classification, site tree data, point-level descriptors, boundary delination, understory vegetation, microplot seedlings, microplot saplings, subplot trees, plot-level note-Mt0, and plot identification-Mt0.

Seven cluster-plots (28 plots) in Pulau Laut, and two cluster-plots (8 plots) in Jambi were established in 1996. Another two cluster-plots (8 plots) were established in 1998 in Jambi. There were seven cluster plots established in 1999, e.g. two cluster-plots in Sumpol, South Kalimantan, and five cluster-plots in Kediri, East Java. Field data measured during the INDO-FHM plot establishment are plot identification, site tree and subplot tree data (horizontal distance, azimuth, DBH and DBH-Check). Crown condition and tree damage by insect and diseases were collected in 1997, 1998, 1999 and 2000. Logging damage were collected once in August 1997. The second measurement of tree DBH was done in August 1997. The third measurement was done in the period of July – August 1998, and at this period the crown density was also measured as well as with densiometer and the sapling data. The fourth measurement was done in the period of

July – August 1999, and the fifth was on July-August 2000. Data on soil physical and chemical characteristic are only recorded at the first and fourth measurements. These field data are in metric unit, class unit, years or FHM Code (see *Forest Health Monitoring - Field Methods Guide (International - Indonesia 1997)* for detail). These field data are recorded using tally sheet or PDR and managed in FHM D-Base® (see Technical Report No. 3). Details on the establishment and the location description of the INDO-FHM cluster-plots can be found in TR 1 : Plot Establishment.

2.1. Tally Sheet

Tally sheet is used to capture field data during the forest mensuration. A new type of tally sheet has been developed for the INDO-FHM Project (see Appendix 1). In this new type tally sheet, crown condition data, tree data, and signs & symptoms data are separated into three different tally, that can be used for four times measurement (for DBH and DBH Check), and three times for crown condition and damage. Point Number and Offset Point in this tally sheet refers to the Cluster Number and Subplot Number, which consists of two and one-digit numeric code respectively. Tree number consist of two-digit numeric code, where Species Name consist of six character alphabetic code (in rare cases, its consist of seven characters).

This species name code refers to the FHM Code regulation for species name, consist of six characters. The first three characters of the code match the first three letters of the genus, the second three characters correspond to the first three characters of the species identifier. As an example, Shojoh is the FHM Code for *Shorea johorensis* and Shopol for *Shorea polyandra.*

Six characters for species code name are usually enough, except in rare cases where the code for two different species is the same (e.g. *Shorea ovalis / Shorea ovata*). In this situation a seventh digit is used for further distinction. A "1" designates the species that is in alphabetical orders, a "2" indicates the species that is second. Due to this regulation, FHM Code for *Shorea ovalis* is Shoova1 and Shoova2 for *Shorea ovata*. List of all the species code name include the rare cases is maintain in FHM D-Base®.

For the unidentified species, the code used is Sp. 1, Sp. 2, Sp. 3, etc. If there is only genus name known, the code will be three characters of the first three letters of the latin genus name and sp1, as an example Litsp1 refer to *Litsea* sp.

Horz. Dist. column consist of three-digit numerical code, used to record the horizontal distance to the nearest 0.1 m from the subplot center to the pith at the base of the site tree. The azimuth record as a three digit code ranging from 001 to 360, capture by view on the base of the site tree with a compass from subplot center.

DBH consist of three-digit numeric code, used to record the diameter of the trees (or poles) masured at (1.3 m) above the groundline, on the uphill side of the tree. DBH-Check used to identify any irregularities in DBH measurement positions (e.g. abnormal swellings, diseases, damage, new measurement positions, etc.). Code for DBH-Check must be "0" if there is no problem with DBH measurement, and "1" for irregular DBH measurement. Whenever code "1" is used, further explanation is required in the notes.

Crown Evaluation Measurements that capture in Crown Structures Tally are live crown ratio, crown density, crown dieback, foliage transparency, and crown diameter wide and 90^0. Each of these crown measurement has two digit numeric code, except the crown diameter (wide and 90^0) that has three digit numeric code.

Signs and Symptoms Tally were used to record any damage and catastrophic assessment. Location 1, 2, and 3 categories have one-digit numeric code, ranging from 0 to 9. Damage 1, 2, and 3 categories are recorded based on the numeric order which denotes decreasing significance from damage 01 - 31. Severity codes vary depending on the type of damage recorded. For the details of used and description of Location, Damage, and Severity Code, also for Crown Evaluation and Site Tree Code, please see *Forest Health Monitoring - Field Methods Guide* (Mangold, 1997).

2.2. Portable Data Recorder

The Portable Data Recorder (PDR) is the field tool used by crews to record and download data. The PDR contains different data collection programs, of which is TALLY. All FHM forest mensuration data; crown condition classification data; and damage and mortality assessment data are collected on PDR with the TALLY program which prompts crews to enter measurement record as they finish doing each measures. TALLY prohibit crews to go to other menu whenever a complete series of measurement is not yet done. TALLY incorporates numerous list, range, and logic checks to verify the accuracy of the data. Please see *Forest Health Monitoring - PDR Guide (International Version 1997)* for detail of the use of PDR and TALLY.

Up till now, PDR has not being used in INDO-FHM mensuration, due to some technical and administration problems.

2.3. FHM D-Base®

FHM D-Base® is the name of database program developed for INDO-FHM project. The first version of FHM D-Base® runs with Window 3.1, and the second version runs under Window97. FHM D-Base® is used to manage data in INDO-FHM project since October 1997.

As a database management system, FHM D-Base plays an important role to prepare and provide information for the users, and also for data analysis. Input data for FHM D-Base® is taken from field data collected in tally sheet. Then FHM D-Base® will process the data into a useful output, such as reports or graphs.

There are some changes in tree coding regulation between tally sheet and FHM D-Base®. Tree identity in FHM D-Base® composed of a combination between numerical and alphabetical characters, as an example 01.4.12/PUL. The first numerical character in tree identity indicates the cluster number 1 of the tree location. The second character (4) indicates the annular plot/subplot number, and the third character (12) indicates the tree number in the subplot or annular plot. The three-digit alphabetical character at the end of code refer to the cluster location, correspond to the first three characters of the cluster location : PUL indicates Pulau Laut and JAM indicates Jambi.

Other coding regulation, such as horizontal distance, azimuth, and DBH code; all crown condition classification code; and all damage and catastrophic assessment code are the same between tally sheet and FHM D-Base® . These similarity is designed to give an easy and simple way for the user to record the field data into FHM D-Base®

FHM D-Base®, like other database program, uses referential integrity among its tables and uses query language to process raw data that have been capturing in tally sheet. These referential integrity and query language will provide the users much more advantages to use this program, so that by following the instructions in this program, any user could operate this program easily. By using this program, any user could get any important information easily, such as trees growth or crown index, as well as to entry new data from tally sheet.

To see detail used of FHM D-Base® or what kind of information FHM D-Base® could provide, please see Technical Report no. 3.

III. DATA ANALYSIS

Data analysis for every criteria and indicator measured, is done according to their respective formula defined in *FHM Field Methods Guide* and *FHM Quality Assurance Project Plan For Detection Monitoring* and some other formulas defined by respective INDO-FHM scientist.

3.1. Site Tree Data

Site tree data consists of tree identity (identity number and species name), tree position (horizontal distance and azimuth), DBH and DBH-Check.

Diameter of trees (or poles) measured at 1.3 m above the ground, on the uphill side on the tree. DBH Check is used to identify any irregularities in DBH measurement positions that invalidate the use of this tree in diameter growth/change analysis. Plant species with 20.0 cm DBH or more are categorized as tree, those with DBH less than 20.0 cm and above 10 cm are categorized as pole.

Poles is being counted only in subplot, while trees being counted both in subplot and annular plot. Differences between DBH measured between two periods of measurement is used to indicate the tree growth.

Total amount of trees, poles, saplings and seedlings recorded in INDO-FHM plots is 3474 (1657 trees and poles, 962 saplings, and 155 seedlings), consist of 1179 (455 trees and poles, 613 saplings, and 111 seedlings) in Jambi, 1165 (996 trees and poles, 125 saplings, and 44 seedlings) in Pulau Laut, 392 (168 trees and poles, and 224 saplings) in Sumpol, and 738 (trees and poles) in Kediri. There are some trees measured at first measurement that had been cut down, burned, dead or falled down so that they can not be measured in the next re-measurement. Some trees more were regenerate from poles to trees or from saplings to poles. Detail information on the stand structure in each FHM cluster-plots can be found in TR 23 : Stand Structure (Status, Change, Trends) and TR 24 : Regeneration and Mortality.

Total species identified in Pulau Laut, Jambi, Sumpol and Kediri is 753 consist of 635 species for trees, poles and saplings; and 118 for seedlings. It consisted of 65 families for trees and poles, and 38 for seedlings. Details on the tree species diversity can be found in TR 4 : Vegetation Structure Indicator, TR 12 : Present Status of Tree Diversity in Jambi, TR 15 : Tree Species Diversity Assessment, and TR 16 : Tree Species Diversity Between NFI and FHM Plots.

3.2. Crown Condition

Crown evaluations describe tree condition. Crown evaluations that quantitavely assess current tree conditions become an integrated measure of site, stand density, and external stresses. Five crown condition indicators are used to assess health or vigor of trees : live crown ratio, crown density, crown dieback, foliage transparency, and crown diameter (wide and 90^0). All of these measurements had done for all trees with a DBH of 20.0 cm or greater in August 1997, 1998, 1999 and 2000. Data analysis for these crown indicators was done by using FHM D-Base®, refer to the *Quality Assurance Project Plan for Detection Monitoring*, such as to weight and scale crown variables and to find the crown index. Reports on crown condition are prepared in TR 6 on present status of crown indicators, TR 9 on crown structure and overstory density, TR 10 and TR 19 on spherical densiometer, TR 20 on crown damage due to logging, TR 28 on crown condition assessment, and TR 29 on canopy condition of overstory trees.

The five crown condition indicators are aggregated into three plot-level indices that reflect the nature of the response of the tree crown to stressors. The variables diameter, ratio and density are aggregated into the CSI, which reflects the morphological nature of these tree variable, i.e., they define the size, shape and fullness of the crown. Crown diameter is weighted more (0.50) than either ratio (0.25) or density (0.25) in the CSI. All variables in the CDI are given equal weights. Although the weighting is subjective, it was based on a strong positive-correlation between crown diameter and dbh. The crown variables comprising CDI, dieback and transparency are a reflection of the condition of the tree foliage, both within the crown transparency and in the sun-exposed outer crown foliage. The third crown index, VCR, is an average of the CSI and CDI.

Detail of equations used to find these weight and scale and formulation being used to find the crown index are described in *FHM Field Methods Guide* and *FHM Quality Assurance Project Plan For Detection Monitoring.*

3.3. Damage Assessment

Damage caused by pathogens, insects, air pollution, and other natural and man-made activities can affect the growth and development of trees. Damage caused by any of these agents, either singly or in combination, can be significantly affect forest health. Identifying the signs and symptoms of damage provides valuable information concerning the forest' condition and indicates possible causes deviation from expected conditions.

This definition of damage was developed to improve data quality and to improve the repeatability of measurements. The damage indicator comprised three separate components, namely : type of damage, location of damage, and severity of damage. For each individual tree, a maximum of three damages can be recorded. By assigning numerical values each component, a cumulative numerical damage estimate for each tree can be developed using the model of **damage = [xDamagetype*yLocation*zSeverity],** where : x, y and z = weighing values based on the relative effect of each component for the growth and survival of a tree. The Damage indexes then divided into three level, e.g. Tree Level Index (TLI), Plot Level Index (PLI), and Area Level Index (ALI). Tree Level Index is formulated as [Damage Type1*Location1*Severity1] + [Damage Type2*Location2*Severity2] + [Damage Type3*Location3*Severity3], Plot Level Index as Average damage [tree1, tree2, tree3, ...], and Area Level Index as Average damage [Cluster1, cluster2, cluster3...]. Reports on damage assessments are prepared in TR 5 on logging damage, TR 11 on forest vitality, TR 17 on damage indicator, and TR 18 on stem damage due to logging.

Detail of equations used to find these weight and scale and formulation being used to find the damage index are described in *FHM Field Methods Guide* and *FHM Quality Assurance Project Plan For Detection Monitoring.*

3.4. Soil Indicator

Soil is but one factor of a habitat, representing the region where a plant community naturally grows. Bearing physical, chemical and biological characteristics, the forest soils are typically stable and resilient bodies that are temporarily altered by natural driving forces like fire and flood.

Plot establishment procedure and soil sampling described by *FHM Field Methods Guide*, was applied on each of FHM cluster-plots. The organic layers and mineral surface layers are collected to be analyzed in the laboratory. The mineral soil analyzed are pH in water and in KCl, total organic carbon, exchangeable Ca, Mg, K, and Na, bray I Phosphorus, CEC and BS, and texture (optional). The organic layers analyzed comprised total organic carbon, total N, and percent organic matter (Loss on ignition, LOI).

Some reports are prepared for the soil indicator, i.e. TR 8 on site quality, TR 21 on soil chemical properties changes, TR 22 on site and species suitability, and TR 26 on study of soil and vegetation dominated by *Shorea polyandra*.

IV. DATA MANAGEMENT

Data is typically manipulated by activities such as calculating, comparing, sorting, classifying and summarizing, thus converting it into information for end users. The quality of any data stored must also be maintained by a continual process of correcting and updating activities. Therefore, data management can be defined as a system to manage data from raw data until the information for end users. So that, process and storage of data take an important role in data management.

Storage is basic system component of data management system. Storage is the data management system activity in which data and information resources are retained in an organized manner for later use. Stored data is commonly organized into fields, records, files and databases (Deans and Kane, 1992).

Tally sheet is being used to record field data from first measurement in 1996 and remeasurement in 1997, 1998, 1999 and 2000, and it had been stored safely up till now. Data were also managed in some reports done in 1997, 1998, 1999 and 2000.

From October 1997, FHM D-Base® has been used to manage all of FHM field data. Up till now, FHM D-Base has managed 6689 recorded data from all INDO-FHM plots. Sorting, classifying and analyzing it were also done so that it becomes a valuable information for the end users. Some rectification of FHM D-Base® are being done to improve it's capability.

V. EVALUATION

It is clear that the FHM D-base® (Technical Report No. 3) is designed not only to allow users to store and analyze their data in ease, but it becoming the "heart" of all FHM activities.

In USDA Forest Service FHM System, PDR (Portable Data Recorder) is the basic tool to record data in the field. The menu system on PDR will not allow scientist to make mistake in data collection, else the PDR will not work. Through data transfer from PDR to PC, no one will be possible to make change to the data collected in the field. Data quality assurance is guaranteed.

It is different with the INDO-FHM methods applied up to now. Scientists going to the field without any computer nor PDR. There is no system to guarantee that the data collected in the field is correct. Therefore, up till now, if the reports published and the contents are sometimes contradictory, it is because the data management is not yet fully controlled by FHM D-base®. Certain formula used by INDO-FHM scientists are not usually in an agreement by the FHM D-Base® administrators, and therefore the administrators are not responsible for any inaccuracies of the results.

However, the advantage of FHM D-base® compare to PDR and USDA-FS FHM is that it is readily available to be used in a laptop or even handheld/palmtop computer in the field and the result could be directly obtained.

FHM D-base® is still in its infancy, and we are continuously developing the improvement as to allow among others are data security through grouping of users limited access, limited menu for data entry control, etc.

Critics and other evaluation to the FHM D-base® are welcomed.

ACKNOWLEDGEMENT

This Technical Report No. 2 on the **Data Collection, Analysis and Management** has been prepared to fulfill Objective 3 point 4.5 of the Work-plan of ITTO Project PD 16/95 Rev. 2 (F) : Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest.

The authors would like to thank ITTO, Ministry of Forestry (GOI), PT. INHUTANI II, PT. Asialog Forest Concession Holder, PT. SUMPOL Forest Concession Holder and Perum Perhutani Government Forest Enterprise for their support. Appreciation also goes to the Project Steering Committee members for their suggestions.

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FOREST HEALTH MONITORING DATABASE (FHM D-Base©) : "USERS GUIDE"

Technical Report No. 3

Erianto Indra Putra
Supriyanto

ABSTRACT

FHM D-Base is the Forest Health Monitoring database management system that basically made up of the referential integrity among its tables. FHM D-Base provides more advantages to the users, containing several report forms and graphs as the output as well as the data entry forms. This guide gives the brief step-by-step instruction on how to operate the FHM D-Base properly, i.e. to open the FHM D-Base, to make the data entry and to get the data output such as in the reports or graphs.

Keywords: *FHM D-Base, instruction, data entry, graphs*

I. INTRODUCTION

FHM D-Base® is the name of database program developed for INDO-FHM project. The first version of FHM D-Base® is made under MS-Access 2.0 and runs with Window 3.1. The second version is made under MS-Access97 and runs under Window97. FHM D-Base® is used to manage data in INDO-FHM project since October 1997.

As a database management system, FHM D-Base plays an important role to prepare and provide information for the users, and also for data analysis. Input data for FHM D-Base® is taken from field data collected in tally sheet. Then FHM D-Base® will process the data into a useful output, such as reports or graphs.

FHM D-Base®, like other database program, uses referential integrity among its tables and uses query language to process raw data that have been capturing in tally sheet. These referential integrity and query language will provide the users much more advantages to use this program, so that by following the instructions in this program, any user could operate this program easily. By using this program, any user could get any important information easily, such as trees growth or crown index, as well as to entry new data from tally sheet. This guide explains the brief step-by-step instruction in operating the FHM D-Base®.

II. WELCOME MENU AND OPENING MENU

When you run this program, you will find the Welcome Menu (Figure 1). By choosing *OK* in the welcome box, you will open the Opening Menu (Figure 2).

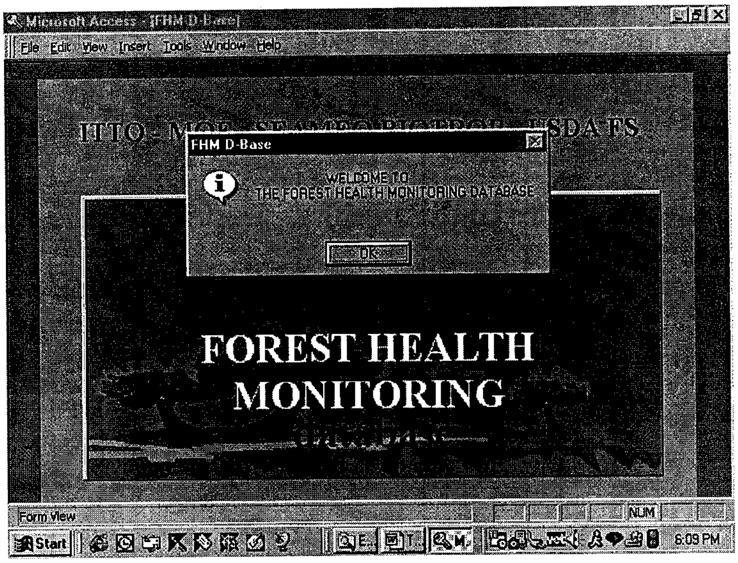

Figure 1. Welcome Menu

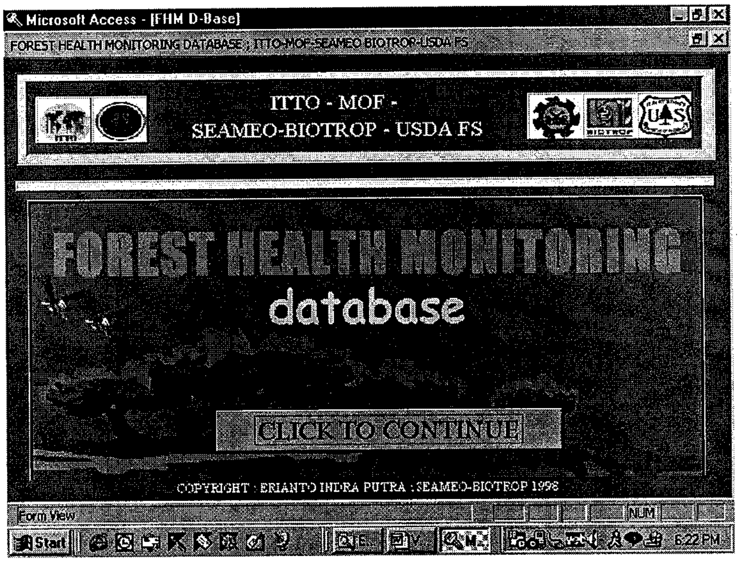

Figure 2. Opening Menu

Please choose the *CLICK TO CONTINUE* button to open the program that will display the first password (Figure 3).

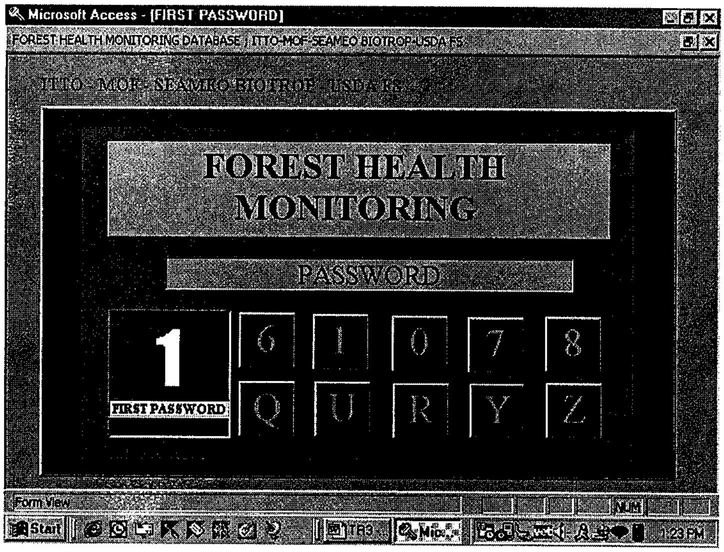

Figure 3. First Password Menu

III. Passwords

This program has the password to protect it from illegal user. There are three kinds of different password menus that you will find after the opening menu. You must enter the correct button on each password menu, e.g. you will pass the first password only if you had entered the correct first password that will bring you to the second password. The Main Menu (Figure 3) will be opened after you pass the third password (Figure 4). Miss-click of the button of each password menu will bring you to trouble.

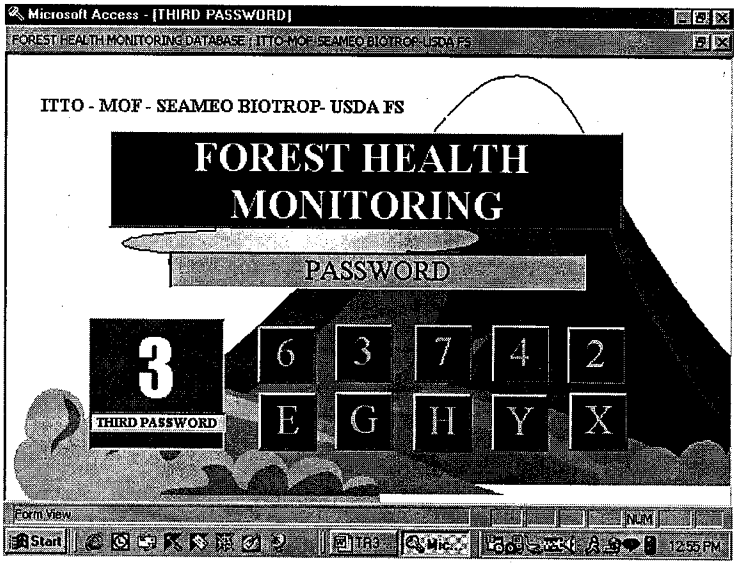

Figure 4. Third Password Menu

IV. Main Menu

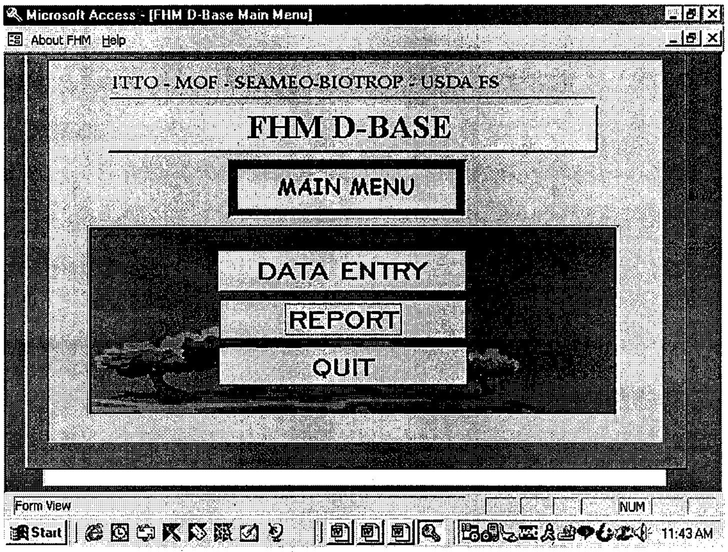

Figure 5. Main Menu

You may open the further program with this Main Menu (Figure 5). In the Main Menu you will find *DATA ENTRY, REPORT*, and *QUIT* buttons. Choosing the *REPORT* button will open the Report Menu, meanwhile by clicking the *DATA ENTRY* button will bring you to the Data Entry Form Menu. You can close the program by clicking *QUIT* button.

V. Report

You could get various reports listed in Report Menu (Figure 6). Different reports are built to meet the data requirements on selected indicator, e.g. tree data, species curve area and trees distribution for the productivity and biodiversity; crown structures data, densiometer data, tree damage and logging damage data for vitality and health; soil chemical and physical properties data for site quality; and socio-economic data for social-economic attributes.

Some reports will ask you to enter the parameter value that will give you the report that you want. For example, to open the tree data report (Figure 8), the program will ask you to enter the cluster location, the cluster number and the plot number. The program will show the tree data in the location, cluster number and plot number that you entered in the parameter value box (Figure 7).

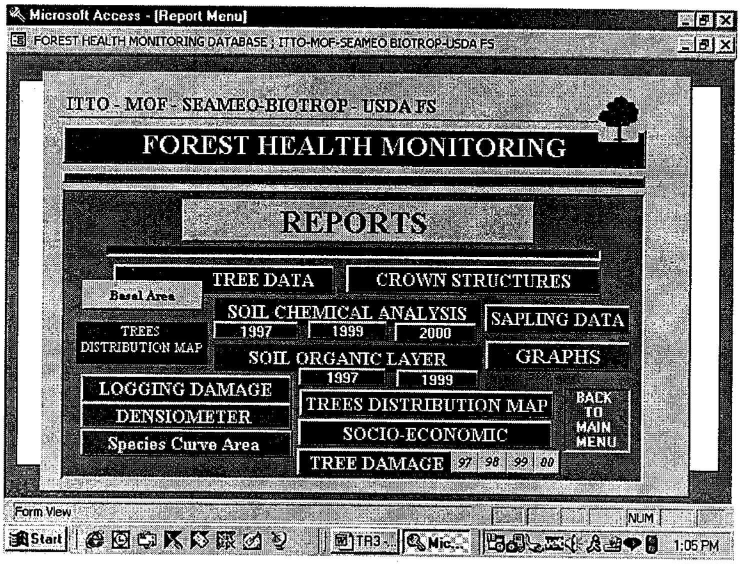

Figure 6. Report Menu

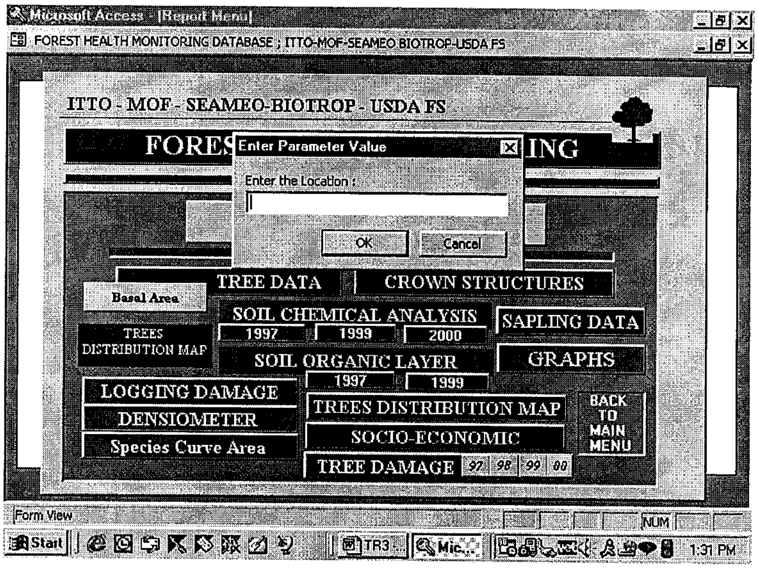

Figure 7. Parameter Value Box

There are two ways to print the report. You can choose *Print* on the menu bar then choose *Print*, or click the Print button. If you want to see the print result before you print it, you can load the print preview from *Print* on menu bar and then choose *Print Preview*. To set up your printer, choose *Print set up* from File. CLOSE button is used to close the report.

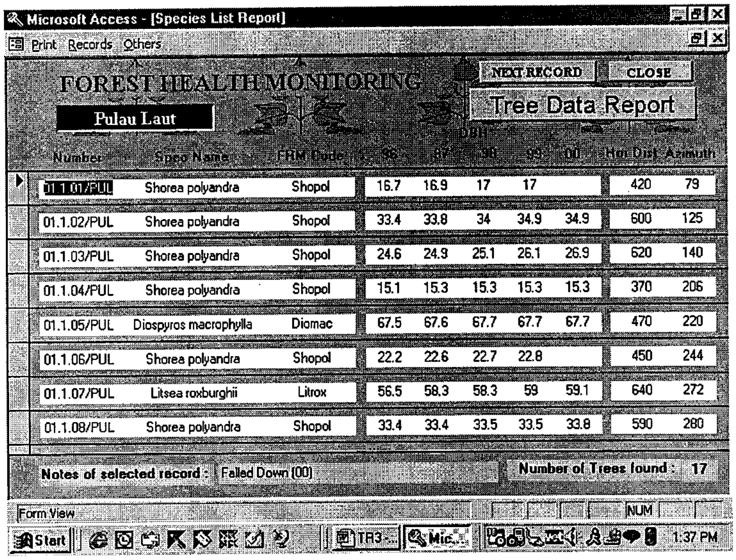

Figure 8. Tree Data Report at Plot 1, Cluster 1, Pulau Laut

You can see the next record, previous record, first record, or last record by choosing *Go To* from Records on the menu bar. You also can see the next record by click *GO TO NEXT RECORD* button. The pointer that you see in the left of the screen refers to the active record. If you click *GO TO NEXT RECORD* button, the pointer will move down.

VI. Graph

Graph is another type of output in this program. You can access all of the graphs listed in the Graph Menu (Figure 9).

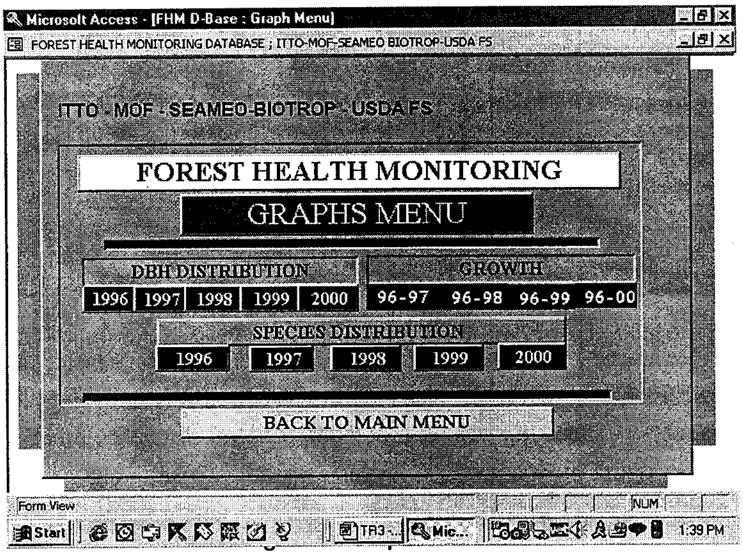

Figure 9. Graph Menu

After you click any type of the graph listed, you will find the parameter value box that ask you to enter the specific criteria to load the graph that you need, i.e. to open the Crown Structure Graph on the specific plot (Figure 11), you must enter the right cluster number on the parameter value box (Figure 10) followed by others parameter value box that asked for the cluster number.

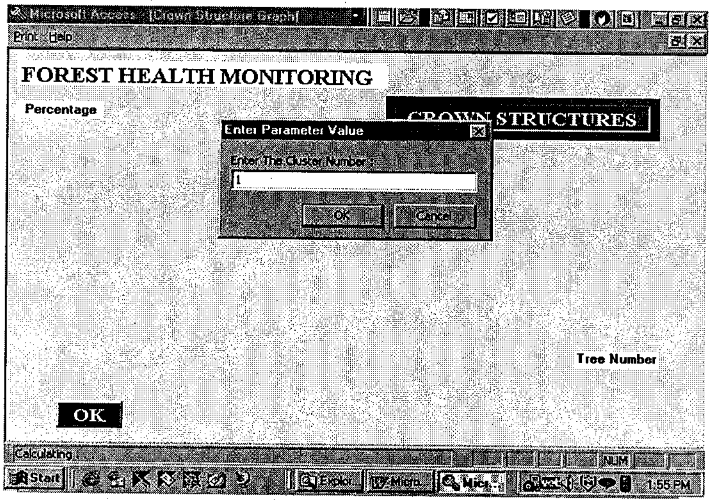

Figure 10. Parameter Value Box

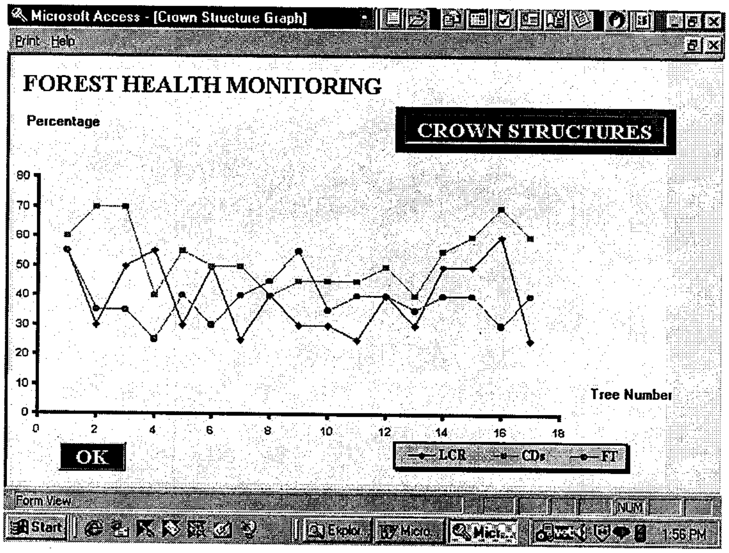

Figure 11. Crown Structure Graph

VII. Data Entry Form

You can add your new data in the data entry form. You can load any type of data entry form listed in Data Entry Form Menu (Figure 12) by choosing the related button. For example, to load the Socio-economic Data form (Figure 13), you must choose *SOCIO ECONOMIC* button.

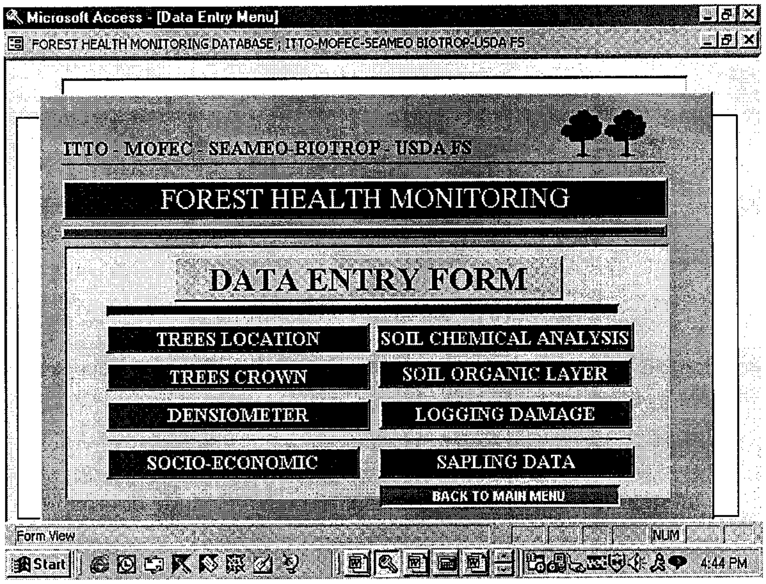

Figure 12. Data Entry Menu

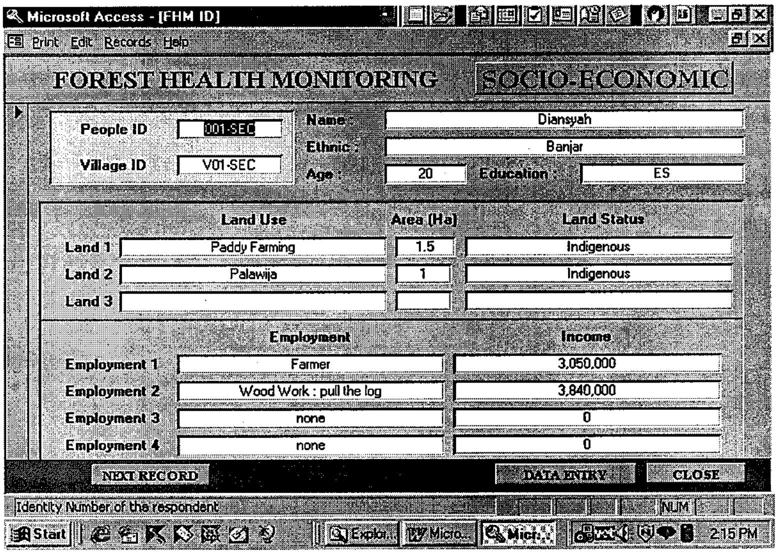

Figure 13. Socio-Economic Form

After loading the form, you can entry your new data, to see the data list or to print the form. In the screen you will see the list of your data. Pointer on the left screen points out the active record. To entry your new data, choose *DATA ENTRY* button or choose *Data Entry* of the *Records* menu that you find on menu bar. By choosing *Go To* from *Records* menu will give you some options, *First, Last, Next, Previous,* and *New*. All of those options refer to the active record. If you choose *First,* the pointer will point out at the first data. If you choose *Last,* the pointer will indicate the last data. To see the next data, you can choose *Next* or you can turn down the pointer with the down arrow button on your keyboard or by using your mouse. *New* has the same function with *Data Entry* from *Records* menu or *DATA ENTRY* button. From *Edit* menu, you will find *Undo/Can't Undo, Cut, Paste* and *Delete* that refers to the active data. These options are useful to help you if there are a lot of similar data. To print the form, choose *PRINT* button or choose *Print* option from the *Print* menu on the menu bar.

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This Technical Report No. 3 on the **Forest Health Monitoring Database (FHM D-base®) 'Users Guide'** has been prepared to fulfill Objective 3 point 4.6 of the Work-plan of ITTO Project PD 16/95 Rev. 2 (F) : Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest.

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VEGETATION STRUCTURE INDICATOR: 'PRESENT STATUS OF TREE SPECIES DIVERSITY'

Technical Report No. 4

Soekotjo
Uhaedi Sutisna

ABSTRACT

The tropical rain forest of Indonesia is widely acknowledged as the richest in terms of species and complex terrestrial ecosystem in the world. The Indonesian Forest Health Monitoring (INDO-FHM) project plans to track the regional status and trends of biodiversity in forests of Indonesia. The objective of this report is to characterize tree species diversity for the FHM sub-plots and annular-plots. Species richness, species evenness, species diversity and species equitability are measured by using well known formulas. The results showed that species richness, evenness, diversity and equitability depend on the sample size and community level. The formulas used meet the following criteria: (1) simple quantification, (2) low environmental impact, and (3) regional responsiveness.

Key words: *Tree species diversity, sample size, community level*

I. INTRODUCTION

Tropical rain forest of Indonesia is widely acknowledged as the most species rich and complex terrestrial ecosystem in the world. Whitmores (1984) demonstrated that small areas of Borneo (Wanariset, Serawak and Kalimantan) rain forest are richer in tree species than similar areas in Africa and most similar areas in tropical America. Conservatively, the flora of Malesiana was estimated by Van Steenis (1971) to comprise 25,000 species of flowering plants.

The global interest in conserving tropical rain forest is in part stimulated by the recognition that it is a treasure house of potentially useful species, whether as a gene pole of domesticated species such as forest plantation, as a source of timber or minor products or biologically active compounds.

In the field of a gene pole, many publications have demonstrated (US Bureau for Science and Technology, 1990; Cohen et. al. 1991; United Nations, 1992; and Soekotjo, 1993) the importance of ex situ genetic conservation in the context of global efforts being made to conserve biological resources, and the critical relation of these effort to future uses of these resources, and the critical relation of these effort to future uses of these resources in response to changing condition.

Genetic materials fulfill crucial function and are key elements in improving our forest resources and stimulating sustainable development. The efficient and wider utilization of genetic materials as the challenge before us for the twenty-first century. This activity will (1) closer linkages with breeders, (2) conservation goal meet for biotechnology, and (3) efficient sharing in network.

In the field of biologically active compounds not less than thousand species of vesicular plants have been reported to have therapeutic properties and have been widely used in various systems of traditional practiced. Recently some of species clinically produce important bioactive compounds e.g. anti tumor, anti malaria, anti hypertensive, contraceptive and others.

Those important of biologically active compounds as part of biodiversity value identifies as wide range of needed research activities to be carried out in the near future. They provided us with a reservoir of future biologically active compounds for modern medicines.

Both genetic materials and biologically active compounds are the source of biologically wealth and foundation of material societies continues to depend on biological materials to their needs.

Indonesian Forest Health Monitoring (INDO FHM) plans to track the regional status and trends of biodiversity in forests of Indonesian. INDO FHM will Investigate relationships between the status and trends of biodiversity indicator with natural and human induced stresses. The vegetation structure indicator is sensitive to human induced stress (Hadi and Supanto, 1977; Burgess, 1973) environmental gradients (Daubenmire, 1968) and forestry practices (Childers *et al*, 1986). Thus, the measurement of biodiversity may be used induced and natural stress.

This report's objective is to characterize tree species diversity for the sub plot and plot. A well known formula of species diversity are used.

Definitions and formula tree species diversity is composed of two distinct components : (1) the total number of tree species and (2) evenness (how the abundance of trees are distributed among the species). A subplot that contains a few individuals of many species will have a higher diversity than that will a subplot containing the same number of individuals but with most of them confined to a few species.

A number of indexes have been developed to characterize species richness and evenness. Indexes that attempt to combine both species richness and into a single value are known as index of diversity. The simplest determination of species richness is to count the number of species, S. Since S depends on the sample line (subplot and annular plot), therefore, it is limited as a comparative index. Hence, in this report we use a well known index of species richness proposed by Margalef (1958) as follows:

$$R_{Mar} = (S - 1) / \ln N$$

Where S = number of species

N = total number of individuals

To calculate index of species evenness, we have to calculate first, the Shannon-Weiner Index (H') then calculate H_{max}. Further, H_{max} can be calculated by

$$H_{max} = \ln S$$

Where ln = natural log

S = number of species

Pielou (1975, 1977) proposed evenness index as follow :

$$J' = H' / \ln (S)$$

When all species in a sample are equally abundant, the species evenness index will be maximum and decrease toward zero as the relative abundance of species diverge a way from evenness.

The index of species diversity incorporate both species richness and evenness into a single value. To quantify the index of species diversity we follow the most widely use which is the Shannon-Weiner index, H'. This can be calculated by :

$$H' = - \Sigma p_i \ln (p_i)$$

Where H'' = diversity of species

S = number of species

p_i = proportion of individuals of the total sample belonging to the i th Species

p_i is estimated as :

$$p_i = n_i / n$$

Where n_i = the number of individuals belonging to the Ith of S species in the sample

n = the total number of individuals in the sample

The indexes of species diversity can be used not only to compare similar communities (*alpha diversity*, Whitmore, 1975) or habitats within a given region (*within-habitat*, MacArthur, 1965) but also *between habitat diversity* (MacArthur, 1965) or *beta diversity* (Whittaker, 1975). Species diversity within and among communities involves three components : spatial, temporal, and tropic.

In summary, definition and calculation of plot level value for each element of heterogeneity and complexity of vegetation are presented in Table 1.

Table 1. Definition and calculation of plot-level values for each element of heterogeneity and complexity of vegetation

Elements	Definition	Formula
Richness	The number of species sampled in an area	$R_{Mar} = (S - 1) / \ln N$
Evenness	The distribution of abundance among the species in a community	$J' = H' / \ln (S)$
Diversity	Synthetic measures that are sensitive to both richness and evenness. Related to the uncertainty of identity of an individual randomly selected in an area. Uncertainty increases with richness and evenness	$H' = - \Sigma p_i \ln (p_i)$

Table 1. (Continuation)

Elements	Definition	Formula
Equitability	Relative diversity of sample in relation to maximum possible diversity of community of S species	$J' = H'/ H'_{Max}$
Patterns Diversity	Variation due to the spatial arrangement of plant cover	Stratification = variability, as coefficient of variation, in total cover per stratum Patchiness = variability, as coefficient of variation, in total cover of each sample

II. METHODS

During the FHM Demo-Plot establishment, we established two clusters located at natural forest in Jambi Province, five clusters located at natural forest in Pulau Laut, South Kalimantan Province, and two clusters located at plantation forest in Pulau Laut. This report concerns only the clusters located at natural forest.

The cluster design is shown in Figure 1 and based on Forest Health Monitoring: Field Methods Guide (Alexander and Bernard, 1996). Each cluster has a tired radius of subplot (7.32 m) and annular plot (17.95 in). Each cluster contains a four-subplot /annular plot (Figure I). A cluster design was chosen because it has proven to be cost effective for extensive surveys (Scott, 1993).

The center of subplot 1 is also considered as the center point of overall plot. The center of subplot 2 is located 360° from the center point of subplot 1 and 36.6 m distance. The center point of subplot 3 is located 120° from the center point of Subplot 1 and 36.6 m distance. The Center of subplot 4 is located 240° from the center point of subplot 1 and 36.6 m distance.

All tree species in each subplot and annular plot were recorded and identified to the lowest taxonomic level. Based on these data, the number of species found on each subplot and annular plot, and also the number of individuals of each species were calculated.

Plot-level indexes of species richness, species evenness and species diversity were calculated using formula described in Table 1.

Specimens of all tree species not known to species level were collected off the cluster, then labeled, pressed and submitted for subsequent identification by a qualified taxonomist.

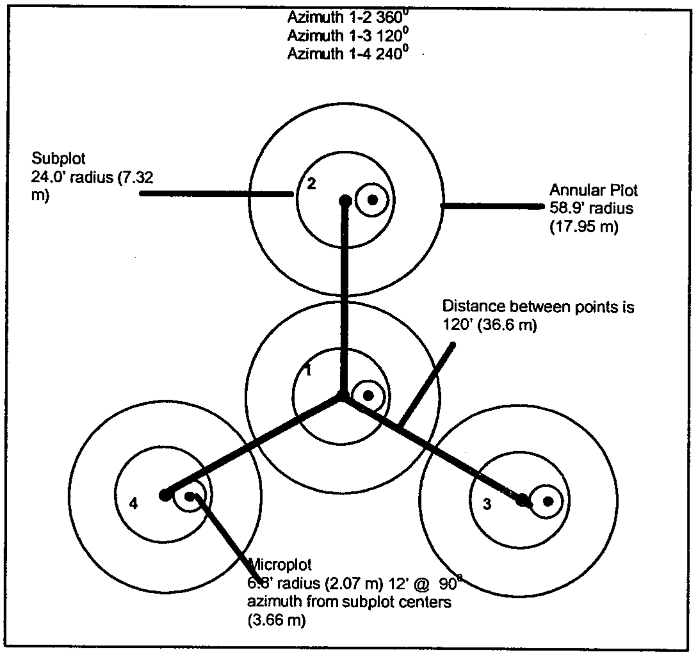

Figure 1. Four FHM plots arrangement of a cluster

III. RESULTS AND DISCUSSIONS

Species richness, evenness, diversity and equitability are presented in Tables 2-4. It is shown that species richness depends on the sample size and community level (Tables 2-4).

The sample size is characterized by subplot and annular plot. Community level is shown in Table 4 for Jambi Community, Table 3 for Stagen Community (Pulau Laut) and Table 2 for Mekarpura Community (Pulau Laut).

As mentioned in the definition, diversity index incorporate both species richness and evenness into a single value. There is obstacle in using this single value as shown in Tables 2-4. The same diversity index value to be obtained for a community with low richness and high evenness as for a community with high richness and low evenness.

Species diversity H' has two properties that have made it a popular measure : (i) H' = 0 if and only if there is one species in the sample (see Table 3, cluster 1), and (2) H' is maximum only when all species are represented by the same number of individuals, that is, a perfectly even distribution and abundance (Table 2, cluster 5 please compare subplots 1-2 vs. subplots 3-4).

An evenness index will be maximum when all species in a sample are equally abundant (Table 4, Cluster 2, Annular plot 2) and decrease toward zero as the relative abundances of the species diverge away from evenness (Table 3, Cluster 1, subplots 2 and 4).

Tables 2-3 describe and quantify elements of biodiversity at Forest Health Monitoring Plot Establishment. Remeasurement of those plots will be used to address trends assessment, that is, whether the elements increasing, decreasing, or unchanged as evaluated with the same formula.

Table 2. Analysis of Tree Species Diversity at Logged Over Areas at Mekarpura, Pulau Laut, by Cluster

	Subplot					Annular plot				
	1	2	3	4	Mean	1	2	3	4	Mean
Cluster 4										
Species Richness	2.79	4.15	2.23	1.89	2.765	2.17	4.46	3.64	2.67	3.235
Species Evenness	1.02	0.86	0.98	0.67	0.833	0.95	0.88	0.92	0.79	0.885
Species Diversity	1.83	2.50	1.58	1.20	1.778	2.74	2.39	2.35	1.73	2.303
Species Equitability	1.02	0.86	0.98	0.67	0.883	0.95	0.88	0.92	0.79	0.885
Cluster 5										
Species Richness	3.37	2.50	1.67	2.27	2.453	4.28	4.09	1.87	3.94	3.545
Species Evenness	1.00	1.09	0.88	0.74	0.928	0.94	0.89	0.74	0.81	0.845
Species Diversity	2.08	2.12	1.42	1.32	1.735	2.49	2.34	1.44	2.14	2.103
Species Equitability	1.00	1.09	0.88	0.74	0.928	0.94	0.89	0.74	0.81	0.845
Cluster 6										
Species Richness	2.88	1.44	3.48	3.09	2.723	4.90	4.08	4.97	4.29	4.560
Species Evenness	0.98	0.95	0.93	0.95	0.88	0.89	0.94	0.86	0.89	0.893
Species Diversity	1.91	1.04	2.16	1.87	1.745	2.54	2.27	2.67	2.27	2.438
Species Equitability	0.98	0.95	0.93	0.95	0.953	0.88	0.89	0.94	0.86	0.893

Table 3. Analysis of Tree Species Diversity at Logged Over Areas Stagen, Pulau Laut by Cluster

	Subplot					Annular plot				
	1	2	3	4	Mean	1	2	3	4	Mean
Cluster 1										
Species Richness	0.96	0.00	1.54	0.00	0.625	1.06	0.00	2.34	0.00	0.850
Species Evenness	0.74	0.00	0.92	0.00	0.415	0.24	0.00	0.81	0.00	0.263
Species Diversity	0.81	0.00	1.28	0.00	0.523	0.67	0.00	1.69	0.00	0.590
Species Equitability	0.74	0.00	0.92	0.00	0.415	0.24	0.00	0.81	0.00	0.263
Cluster 7										
Species Richness	0.51	0.83	1.03	1.68	1.025	2.00	1.86	1.81	2.17	1.960
Species Evenness	1.85	0.54	0.73	0.91	1.008	0.61	0.50	0.64	0.73	0.620
Species Diversity	1.28	0.59	0.80	1.26	0.983	1.19	0.98	1.15	1.42	1.185
Species Equitability	1.85	0.54	0.73	0.91	1.008	0.61	0.50	0.64	0.73	0.620

Table 4. Analysis of Tree Species Diversity at Logged Over Areas at Jambi, by Cluster

	Subplot					Annular plot				
	1	2	3	4	Mean	1	2	3	4	Mean
Cluster 1										
Species Richness	4.17	2.88	3.04	3.75	3.460	5.35	5.00	6.44	6.21	5.750
Species Evenness	0.99	0.98	0.95	0.95	0.967	0.93	0.99	0.99	0.98	0.973
Species Diversity	2.38	1.91	1.97	2.26	2.130	2.70	2.77	3.05	2.98	2.875
Species Equitability	0.99	0.98	0.95	0.95	0.967	0.93	0.99	0.99	0.98	0.973
Cluster 2										
Species Richness	3.75	3.37	3.79	4.03	3.735	4.95	5.54	6.36	5.66	5.628
Species Evenness	0.98	1.00	0.92	0.96	0.965	1.02	1.07	1.03	0.94	1.015
Species Diversity	2.25	2.08	2.21	2.29	2.080	2.78	3.02	3.18	2.76	2.935
Species Equitability	0.98	1.00	0.92	0.96	0.965	1.02	1.07	1.03	0.94	1.015

IV. CONCLUSIONS

The formula used meet the following criteria :

(1) Simple quantification
Data used in tree diversity quantification are the same as used in mensuration indicator. When the data are already in the computer all calculation can be done by computer

(2) Low environmental impact
Since the data used in tree diversity are the same as used in mensuration, therefore, data gathering have little impact beyond the disturbance from walking

(3) Regional responsiveness
The measures of tree diversity in this report are using well-known formula that have been used in many ecological studies in nearly all major ecosystems. Table 2-4 show regional responsiveness

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ASSESSMENT ON THE EFFECTS OF MECHANICAL LOGGING ON RESIDUAL STANDS : "LOGGING DAMAGE, STATUS CONDITION"

Technical Report No. 5

Soekotjo

ABSTRACT

Monitoring the effects of mechanical logging on residual stands was done on off plot of Forest Health Monitoring. The study area located at Compartment 7 of PT. INHUTANI II, Mekarpura, Pulau Laut, South Kalimantan. In this compartment, 12 quadratic plots of 50 m X 50 m were used to monitor the damaged. Among the data recorded of each tree in every sample plot are: number, position, species, and damage type, location and severity codes. The result shows that the damage types vary in sample plot with the total damage comprising 32% of total healthy residual trees. Most of the bark damage of meranti and keruing groups are located at lower bole followed by lower and upper bole, and root and lower bole at 75%, 9%, and 6%, respectively. Broken off is the most severe damage, and the least severe is broken branches. Regression equations of total damage type (Y1), average severity of damage (Y2) and damage indices (Y3) on the amount of exportable trees extracted (X) are expressed as Y1 = 87.13 – 13.02 X; Y2 = 2.59 + 0.78 X, and Y3 = 45.92 + 27.71 X, respectively.

***Key words**: logging damage, damage type, location, severity, damage indices*

I. INTRODUCTION

Long term monitoring on the effects of mechanical logging on residual stands to facilitate sustainable forest management is badly needed. This monitoring is done on off plots of Forest Health Monitoring, located at forest area of PT INHUTANI II, Mekarpura Pulau Laut.

Logging operations are conducted according to Forest Operation Plans in the form of Annual Working Plans, Five - Year Working Plans, and Twenty Year Plans which have to be approved by the Office of Ministry of Forestry, Government of Indonesia. According to **Indonesian Selective Cutting and Replanting System (TPTI)** the timber companies can harvest veteran and mature trees with diameter above 50 cm in Production Forests (Hutan Produksi) or 60 cm in Limited Production Forests (Hutan Produksi Terbatas). Approximately 25 young uninjured or healthy trees of commercial species are left per hectare. These residual trees should be well distributed, and are necessary to ensure the future crop of timber.

After logging, residual inventory is carried out at 100 % intensity for commercial trees 20 cm diameter and up to determine the number of young healthy trees of commercial species and the amount of damage. This is supposed to secure sustained harvest with little loss of biological diversity.

Regeneration inventory is done by linear sampling, ten - four square meter per hectare. If less than 40 % of the plots contain seedling belonging to commercial species, enrichment planting should be done. Enrichment planting is also suggested on skid road and log yards of logged over areas. Tending to free regeneration from competition should be done as needed.

Logging operation utilizing heavy equipment will obviously change the environment of forest stands and cause many predictable and/ or unpredictable problems. Felling and skidding cause logging damage to residual stands (Syachrani *et al,* 1974; Soekotjo *et al,* 1976 ; and Tinal and Palenewen 1978). However, logging also stimulate the growth of undamaged trees as demonstrated by Miller (1980) and Soekotjo (1981).

Sustained forest management requires a large number of information to facilitate the company operations and forecast future development. The objectives of this study are : (1) to obtain type , location and severity of damage of residual trees due to mechanical logging , (2) to evaluate the intensity of logging on type, and severity of damage, and (3) to support Detection of Forest Health Monitoring as future reference.

II. MATERIALS AND METHODS

2.1. Plots establishment

The study area is located at Sub Unit PT INHUTANI II Mekarpura forest area. The plots are located in Block II, Compartment 7. In this compartment two belts of transect are laid out. Each belt of transect is divided into quadratic of 50 m X 50 m. Each quadrate is considered as a sample plot. The total areas of sample plots are three hectares.

Plots boundaries were carefully painted to ensure that the plots could be found for subsequent measurement (re-measurement of long term program). All trees 20 cm diameter and up were numbered with aluminum tags nailed to the tree at the base of trunk or at the buttress. At the point of measurement of each tree, a ring was painted at 1.3 m height. Trees were identified based on their position by azimuth and distance from the center of sample plot. Their name were identified and the diameter were measured with diameter tape to the nearest cm.

2.2. Logging damage

The extent of damage or injury of residual trees due to mechanical logging varies with intensity of logging. Residual inventory determines the extent of damage of residual trees, as a check whether the number of trees for future crops left uninjured and how many of them are damaged. In order to be able to conduct timber stand improvement to guaranty both quality and quantity of the stand left after logging, identification of logging damage (type, location and severity) is of a paramount important. For implementing residual inventory, coding of logging damage is considered as practical once. In this case, I used Field Method Guide of Forest Health Monitoring (Alexander and Bernard, 1997).

Table 1. Code and definition of damage type

Code	Definition
03	**Open wounds or Bark damage** An opening or series of opening where bark has been removed or the inner wood has been exposed.
21	**Loss of apical crown or terminal crown** The terminal crown is broken by felling of tree, at the threshold of 90 - 99 %, Code 21 = Code 31
22	**Crown damage or broken** Branches or segments of crown were broken
31	**Total crown broken** Trees knocked over by falling trees so that the total crown are broken off.
21/ 03	**Crown and Bark damage** This code also indicates that crown damage is more severe than open wounds. However, the reverse condition is also possible (03/22).

The code is of paramount important for long term monitoring and to document changes in tree health over time. In this regard, evaluators have to be trained and certified to maintain high quality control.

The location of damage is also coded using the same way (Alexander and Bernard, 1997) as shown in Table 2.

Table 2. Code and definition of damage location

Code	Definition
2	**Roots** and **lower bole**
3	**Lower bole** lower half of the trunk between the **stump** and base of the live crown

Table 2. (Continuation)

4	**Lower and upper bole**
5	**Upper bole** Upper half of the trunk between **stump** and base of the live crown
6	**Crown stem** Main stem within the live crown area, above the base of the live crown
7	**Branches** on branches of the crown

Multiple location of damage is possible for example **bark damage** (03) located at **lower bole** (3) and **lower and upper bole** (4). It is also possible **two types of damage** on one tree for example **crown damage** (22) and **bark damage** (03). In this regard, the location of crown damage (22) is on crown branches (7) and bark damage (03) is on lower bole (3), for example : 22 7 and 03 3

The definition of severity of damage was developed to improve data quality and to improve repeatability of measurement. Only those damage that could have potential effect on the quality or growth potential on long term bases are recorded. The minimum threshold of severity of damage for each of damage type is proposed. The minimum threshold for apical loss is 1 % and for crown damage is 20 % and bark damage is also 20 %.

Table 3. Severity classes code for open wounds or bark damage (Alexander and Bernard, 1997)

Classes (%)	Code
20 - 29	2
30 - 39	3
40 - 49	4
50 - 59	5
60 - 69	6
70 - 79	7
80 - 89	8
90 - 99	9

The damage area of open wounds is measured at the widest point between the margin of the exposed wood within any 0.91 m vertical section in which at least 20 % of circumference is affected at the point of occurrence (Alexander and Bernard, 1997).

Table 4. Severity damage classes code for Code 21(Alexander and Bernard, 1997)

Classes (%)	Code
20 - 29	2
30 - 39	3
40 - 49	4
50 - 59	5
60 - 69	6
70 - 79	7
80 - 89	8
90 - 99	9

Any occurrence (more than 1 %) is recorded. Severity class is in 10 % as a percent of the crown stem affected. There are two ways to estimate percent crown affected for Code 21 : (1) from the crown left try to find apical crown stem where the previous terminal was (in imagination), thence estimate percent affected, (2) if any tree in the same species and diameter may be used (for comparison) to estimate the amount apical crown stem affected.

Table 5. Severity class for Code 22

Classes (%)	Code
20 – 29	2
30 – 39	3
40 – 49	4
50 – 59	5
60 – 69	6
70 – 79	7
80 – 89	8
90 – 99	9

The amount of branches loss due to logging or crown damage, the threshold is 20 percent (Alexander and Bernard, 1997), as shown in Table 5.

2.3. Damage indices

Saltman and Lewis (1994) introduced formulation of damage index / indicator. The damage is a function of three elements :

damage = f(TYPE, LOCATION, SEVERITY)

By giving the TYPE, LOCATION, SEVERITY value of numerical equivalents, a numerical damage estimate can be calculated by Saltman and Lewis (*loc cit)* using the following model :

damage = w* (TYPE*LOCATION*SEVERITY*)

where : w = weighting factor to have the index values range from 0 to 100.

Due to the fact that each tree may have more than one damage, so tree level damage can be estimated as follow :

tree level damage = w* (TYPE1*LOCATION1*SEVERITY1* + TYPE2*LOCATION2*SEVERITY2* +.........)

Finally the plot level damage index can be estimated by averaging the tree level indices for each plot as follows :

plot level damage index = average damage(tree1, tree2,.............)

According to Saltman and Lewis (*loc cit)* the damage index as described above, will provide a clear, unambiguous numerical relationship between the level of damage on plot or on any tree and the index. However, this calculation still contain limitations due to mask single damage outliers. This index does not differentiate between a single tree with one severe damage and a single tree with tree small damage.

2.4. Measurement

A crew team consists of four persons was conducted the measurement. One person is responsible to estimate logging damage, one person is responsible to measure tree diameter, and two persons are responsible to measure tree position (azimuth and distance of each tree to the center of plot). The person responsible to estimate logging damage also become crew leader, so he also responsible to write all data in tally sheets.

Data recorded for each tree including : number, position (azimuth and distance from the center of sample plot), species (full common name written out) and diameter in cm. Then observe its damage at every face of the **stump, bole, or crown stem** using code describe above. About 40 % of the circumference of a face can be observed at any time. Data from the field (tally sheets) were transferred into **data base** in computer.

III. RESULTS AND DISCUSSIONS

3.1. Results

Table 6 indicates that the number of trees before logging (tree(s) be cut + number of trees damage + healthy residual stands) per hectare are variable, from 156 trees per hectare to 256 trees per hectare.

Table 6. Matrix plot number, trees be cut and types of damage

Plot No.	Number of trees per 0.25 hectare								Sev.	Type
	trees be cut	No damage	damage code 03	damage code 21	damage code 22	damage code 31	combination of damage	remarks		Y (%)
1.1	1	35	7	1	1	2	0	4 11	3.33	24 1
1.2	1	39	0	0	1	5	1	3 7	--	15 1
1.3	3	33	2	9	1	9	1	5 12	6.57	27 3
1.4	2	44	0	2	3	1	1	4 7	4.50	14 2
1.5	5	28	2	2	1	5	1	5 11	6.27	28 5
1.6	2	24	3	4	5	3	0	4 15	4.06	38 2
2.1	5	22	13	5	0	8	2	4 28	4.59	56 5
2.2	2	34	7	5	0	6	2	4 20	6.00	37 2
2.3	2	36	3	3	1	2	2	5 11	3.27	23 2
2.4	0	37	2	0	0	0	0	1 2	--	0 0
2.5	1	44	4	2	0	0	0	2 6	2.83	12 1
2.6	0	63	0	0	0	1	0	1 1	--	0 0
Per hectare		1756	172	132	52	168	40	564		32%

The number of trees to be cut also varies from 4 trees per hectare to 20 trees per hectare. The number of healthy residual trees is presented in Table 7.

Table 7. The number of healthy commercial residual trees per hectare

Plot number	Meranti group	Keruing group	Other commercial	Total number
1.1	40	32	8	80
1.2	48	44	12	104
1.3	16	20	28	64
1.4	60	28	4	92
1.5	48	40	0	88
1.6	16	48	0	64
2.1	64	8	0	72
2.2	72	8	0	80
2.3	24	40	0	64
2.4	24	44	0	68
2.5	24	48	8	80
2.6	16	28	88	132

The future cutting cycle depends to a large degree on the amount of healthy residual of commercial trees as shown in Table 7. Depending on group of commercial species the number of residual healthy trees is variable (Table 7). The number of meranti group plus keruing group per hectare as shown in Table 7 is larger than the requirement described in Indonesian Selective Cutting and Replanting Systems, which is 25 commercial trees per hectare.

The location and severity of bark damage of meranti and keruing group is presented in Table 8.

Table 8. The location and severity of bark damage of meranti and keruing group

Plot Number	Number of trees damage	Location	Severity
1.1	2	3	1
	1	3	2
	1	4	1
	1	4	2
1.3	1	3	1
1.6	1	3	1
	1	3	2
	1	1	2
2.1	9	3	1
	1	3	2
	1	3	5
	1	2	1
2.2	1	3	2
	1	3	6
	1	3	8
	1	2	2
2.3	1	3	1
	1	3	2
	1	4	2
2.4	1	2	4
	1	5	3
2.5	1	3	2
	1	3	3

Table 8 informs us that most of bark damage of meranti and keruing group are located at lower bole (75 %) then followed by lower and upper bole 9 % and root and lower bole 9 %. For severity of damage, 50 % of bark damage is considered less than 20 % damage class, 31 % between 20 to 29 % damage class, 6 % between 30 to 39 % damage class (Table 3). Terminal crown damage is shown in Table 9.

Table 9. Terminal crown damage of meranti and keruing group

Plot number	Number of trees damage	Location	Severity
1.1	0	0	0
1.2	0	0	0
1.3	1	6	30
	1	6	60
1.4	1	6	70
1.5	1	6	40
1.6	2	6	10
2.1	2	6	10
	2	6	60
	1	6	70
2.2	1	6	50

Table 9 indicates that 39 % of trees losses 10 % of their terminal crown, 18 % very severe which losses 70 % of their crown. The total crown loss or broken off is presented in Table 10.

Table 10. The total crown loss or broken off of meranti and keruing group

Plot number	Number of trees broken off	Location	Severity
1.2	1	6	100
1.3	2	6	100
1.5	3	6	100
1.6	2	6	100
2.1	7	6	100
2.2	2	6	100
2.3	1	6	100

The information on crown damage or broken branches is shown in Table 11.

Table 11. Crown damage/ broken branches

Plot Number	Number of trees broken branches	Location	Severity
1.1	1	7	10
1.4	2	7	20
1.5	2	7	10
1.6	1	7	10
	1	7	20
	1	7	80
	1	7	10

Table 11 informs that only one tree of *Shorea johorensis* losses 80 % of its branches, the other less than 20 % loss of their branches. Data on combination of damage or trees having both bark and crown damage is presented in Table 12.

Table 12. Combination of both bark and crown damage

Plot number	Number of trees damage	Location	Severity
1.2	1	4/6	1/1
1.3	1	4/6	4/3
1.4	1	4/6	3/8
1.5	1	5/6	2/4
2.1	1	5/7	1/3
	1	4/6	4/7
2.2	1	3/7	1/1
	1	5/6	4/6
2.3	1	2/6	1 / 2
	1	2/6	1/1

Using Saltman and Lewis (1994) 's formula, damage index is presented in Table 13.

Table 13. Damage index of meranti and keruing group

Plot number	Damage index calculated based on Saltman and Lewis (1994)'s formula
1.1	47.0
1.2	72.8
1.3	154.7
1.4	291.2
1.5	136.5
1.6	16.4
2.1	218.4
2.2	191.1
2.3	84.6

3.2. Discussions

Table 6 illustrates the overall picture of damage types of residual stands in the 12 sample plots under study. Damage types are variable in each sample plot. The minimum damage was found in Sample Plot Number 2.6 (one tree) and Sample Plot Number 2.4 (two trees). In Sample Plots Number 1.3, 1.5 and 2.3 all of damage types were found. Four out of five damage types were found in Sample Plot Number 1.1, 1.4, 1.6, 2.1 and 2.2. The total damage in 12 sample plot comprises 32 % of total healthy residual trees.

The location and severity of damage of meranti and keruing group of species are presented in Table 8 to 12. The location of bark damage varies (Table 8). The most common location are at lower bole (Location 3), followed by lower and upper bole (Location 4) and roots and lower bole (Location 2) .While location at upper bole is very rare. This location of damage is only found in Sample Plot Number 2.4

The location of terminal crown damage is at crown stem, which is in the main stem within the live crown area, above the base of the live crown. When the location of damage is at the base of the live crown, the damage become broken off or total crown loss. If the location of damage is at branches, type of damage is called crown damage or broken branches.

The extent of damage on residual trees as presented in Table 8 to 12 are relatively low severity, most of the damage are less than the minimum threshold. In respect to bark damage , especially for meranti and keruing group of species, the condition of damage above threshold are only found in Plot Number 2.1 one tree, Plot Number 2.2 two trees and Plot Number 2.4 two trees (Table 8). However, when the wounds allow entry of pathogens into the stem, we have to consider this type of damage more seriously . In the case of crown damage, Nicholson (1958) considers that only 50 % to 90 % crown damage affects growth and health of trees seriously. Let assume that the threshold of crown damage is 50 % of its branches loss, Table 11 informs that for meranti and keruing group of species, the condition of damage above threshold is only found in Plot Number 1.6 for one tree.

Broken off is the most severe of damage, and the least severe is broken branches. Few species will survive under broken off type of damage. The total number of meranti and keruing group of species which have broken off type of damage is 9 trees per hectare. However, when this figure is compared with data on healthy residual stands of meranti and keruing group of species (Table 7) the figure is relatively low.

The number of trees be cut is variable from 0 to 20 trees per hectare, and the average is 4 trees per hectare (Table 6). This variation is mainly based on the pattern of spatial distribution of dipterocarp species. Many of meranti species, their spatial distribution are never or very rare in uniform distribution. Most commonly spatial distribution of meranti and keruing species are **clumped pattern** or **random pattern.** When its spatial distribution belong to clumped pattern, and other meranti in random pattern the average number of trees be cut varies from 11 to 17 trees per hectare. In this study 2 out of 12 plot, the number of trees be cut up to 20 trees per hectare (Table 6).

The next question is correlation between trees be cut and the amount of type of damage/ severity of damage. The regression equations of total damage type, average severity of damage and damage indices are as follows :

$$Y = 87.13 - 13.02 X$$

Where Y = total damage type expressed in percentage of injured trees

X = amount of exportable trees extracted

$$Y = 2.59 + 0.78 X$$

Where Y = average severity of damage

X = amount of exportable trees extracted

$$Y = 45.92 + 27.71 X$$

Where Y = damage indices

X = amount of exportable trees extracted

The total healthy residual trees of commercial species varies from 64 trees per hectare to 132 trees per hectare (Table 7), while the requirement prescribed in Indonesian Selective Cutting and Replanting System is 25 healthy trees of commercial species per hectare and distributed randomly in all areas. The healthy residual trees of meranti and keruing group varies from 36 trees per hectare to 88 trees per hectare. This number of residual trees of meranti and keruing group is also very much higher than the prescribed number in the Indonesian Selective Cutting and Replanting System. Based on Table 7, the healthy residual trees of meranti and keruing group is adequate to assure the second cutting cycle.

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PRESENT STATUS OF CROWN INDICATORS

Technical Report No. 6

Simon Taka Nuhamara
Kasno

ABSTRACT

This report discusses the present status of crown condition of the trees assessed in the cluster-plots of both study sites, Pulau Laut and Jambi. During this assessment, the data collected is related to the growth of some important trees. However, further data are needed so as to explain on how good is the crown condition selected as one of the forest health indicators, especially in relation to the tree growth.

Keywords: *crown indicator, forest health, Pulau Laut, Jambi*

I. INTRODUCTION

1.1. Background

Forest Health Monitoring Program using a progressive methods and procedures has been widely practiced, especially, in US Forest areas (USDA Forest Service, 1997). It is known that such program is relatively new technique in monitoring forest health and its sustainability. Looking at the very sound program , Government of Indonesia is interested to test the methods and eventually to adopt it if possible for similar purpose in the near future.

A multitude of abiotic and biotic influence shape forest trees. Individual tree vigor and growth are influenced by physiological age and available water, nutrients, and light resources at a site (Cline and Williams, 1995).

A tree position relative to its neighbors is also critical in determining the amount of water, light, and nutrient available for any one tree. Therefore tree-stand interactions require that stand-level data be collected.

Crown evaluation describes tree conditions. An observed tree condition reflects the preceding year's growth processes, influenced by site, stand density, and external stresses. Therefore, crown evaluations that quantitatively assess current tree condition are really an integrated measure of site, stand density, and external stresses from the preceding decade or earlier.

Assessing crown condition is a part of FHM activities. As part of the techniques, crown assessment has been long tested in the US forest types and condition. As a new developed technique, through time, possible improvement and adjustment to the technique may be made to obtain a better quality of data interpretation. Therefore USDA Forest

Service has made annual revision to improve the technique in solving the proceeding year's field problems. Such long tested technique in the US forest types and conditions, probably, will not be automatically applicable to the Indonesian tropical rain forest conditions. It is suspected if the technique is applied on so much different forest types and conditions, there will need an adjustment.

This report discusses the five indicators of crown condition (**live crown ratio, crown diameter, crown density, crown dieback and foliage transparency**) which are used to assess the health or vigor of trees in the tested plots.

1.2. Objectives

1. To test the applicability of crown assessment as part of the FHM technique in tropical conditions.
2. To present the forest tree health status of the tested plots / areas using crown indicators

II. MATERIALS AND METHODS

2.1. General description of the study areas

This technical report discusses the same forest trees species established by the ITTO Project in Pulau Laut for different indicators studied.

Five out of seven cluster plots were established in Stagen and Mekarpura both in Pulau Laut, South Kalimantan. All of the cluster plots were established in 1996 (See Technical Report No. 1 on Site and Plot Establishment). Clusters in Pulau Laut are established in a natural production forest.

All crown indicators were measured on all trees with a diameter at breath height (DBH) of 5 inches (12.7 cm) or greater on each 1/24-acre subplot, which is classified as forested.

2.2. Definitions and Procedures

The following definition and procedures for measuring crown condition are adopted from Forest Health Monitoring Field Methods Guide (International – Indonesia issued by USDA Forest Service (1997)

1. **Live crown ratio** is a measure of crown length and its relationship to total tree height (denoted in percentage and divided into 21 classes)
2. **Crown diameter** is the average of two measurements: a) widest distance anywhere in the crown between two live branches and b) the perpendicular distance to the widest measurement (in ft or meters)

3. **Crown density** is the amount of crown branches, foliage, and reproductive structures that block light visibility through the crown (in percentage; divided into 21 classes)
4. **Crown dieback** is defined as branch mortality with begins at the terminal portion of a branch and proceeds toward the trunk and/or the base of the live crown (in percentage ; divided into 21 classes)
5. **Foliage transparency** is defined as the amount of the skylight visible through the live, normally foliated portion of the crown or branch (in percentage; divided into 21 classes)

(All crown variables were recorded at 90 % in agreement of data quality limits)

2.3. Data review, Reduction, Verification, Validation and Formula used

- **Crown Diameter** = [(Crown Diameter Wide) + (Crown Diameter at 90 degrees)]/2
- **Weighting and Scaling Crown Variable**

✱ The effects of some specific stressors, such as stand stocking, are adjusted for the crown variable density, ratio and diameter, by calculating a competition factor (CF) for each tree using equation 1:

$$CF_i = \frac{1}{dbh_i} * \sum_{j=1;\, j\neq 1}^{n} \frac{dbh_j}{dist} \qquad [1]$$

where **dbh_i** is the diameter at breath height of subject tree, **dbh_j** is the diameter at breath height of all comparison trees in the subplot, and **dist** is the distance factor.

The CF-weighted tree score is then scaled for each species and crown position group. The general form for scaling is:

$$\textbf{Scaled Value} = 100 * (obs - min) / (max - min) \qquad [2]$$

Where min is the minimum tree-level observed, max is the maximum tree level observed, and obs is the individual tree-level value.

2.4. Index Formulation

The five crown variables are aggregated into three plot-level indices that reflect the nature of the response of the tree crown to stressors (Cline and Williams, 1995). The variables diameter, ratio and density are aggregated into the CSI, which reflects the morphological nature of these tree variable, i.e., they define the size, shape and fullness of the crown.

The crown variables comprising **CDI**, dieback and transparency are a reflection of the condition of the tree foliage, both within the crown transparency and in the sun-exposed at outer crown foliage. The third crown index, **VCR,** is an average of the CSI and CDI. The general form for each index is:

$$CSI = (0.5)Diameter_{SC/CF} + (0.25)Ratio_{SC/CF} + (0.25)Density_{SC/CF} \quad [3]$$

$$CDI = (Transparency + Dieback) / 2 \quad [4]$$

$$VCR = (CSI + CDI) / 2 \quad [5]$$

Where SC is the scaled value, and CF is the normalized competition factor.

III. RESULTS AND DISCUSSIONS

3.1. Results

There are so many tree species in all plots. To make more simple data analyses, three commercial tree species such as *Shorea polyandra, S. johorensis,* and *Dipterocarpus caudiferus* are chosen for presenting crown status as shown in Table 1.

Live crown ratio of *S. polyandra* and *S. johorensis* are about the same which is 32.5 and 31.25 respectively. The same indicator for *D. caudiferus* is 52, which is higher than that of the two *Shorea polyandra, S. johorensis*. For crown diameter, the three species have more or less the same figures 8.31, 8.59 and 8.98 respectively. The same trend was also observed for crown density, and all the three species have crown density of 70, 60.63 and 73 respectively. Observation on crown dieback at the time, revealed low figures for all tree species measured. This is also observed on the three tree species mentioned. They have 2.5, 4.38 and 3 respectively. For crown transparency, again the three tree species have more or less the same figures that is 32.5, 36.87 and 27 respectively.

Table 1. Crown Conditions of The Main Economically Important Tree Species in Pulau Laut (Cluster 4)

Indicators	Tree Species		
	Shorea polyandra	*S. johorensis*	*D. caudiferus*
Live Crown Ratio (%)	32.5	31.25	52
Crown Diameter (m)	8.31	8.59	8.98
Crown Density (%)	70	60.63	73
CSI	**815.21**	**546.91**	**1085.13**
Crown Dieback (%)	2.5	4.38	3
Crown Transparency (%)	32.5	36.875	27
CDI	**17.5**	**20.63**	**15**
VCR	**416.36**	**283.77**	**550.07**

To show the change, possible correlation between the preceding year's stem diameter / growth and crown index, the paired data were displayed in the logarithmic trend. In showing more specific crown conditions, the following are the relationship between growth and crown index of *S.polyandra, S .johorensis* and *D. caudiferus* in corresponding cluster plots (Figures 1-5). More detail data of the same trees can be seen in Tables 1-3 of the Appendix.

- *Shorea polyandra*

Figure 1 shows the relation between growth and VCR of *S. polyandra* growing in cluster 1 as affected by its crown indicator.

The data revealed that the optimum growth increment of 1.63 cm after one year measurement, is best performed by its crown indicators (VCR) index, range just below and above 500.

On the other hand, Figure 2 shows slightly difference response of the same species observed in cluster 7. In this cluster, the tree species has an optimum growth increment only around 1.2 cm at VCR index between 600 and 700.

- *Shorea johorensis*

Figure 3 shows quite logic relationship between growth and VCR, from 900 through 1700 of VCR index at the highest growth increment of 1.5 cm.

- *Dipterocarpus caudiferus*

Figure 4 indicates that optimum growth increment of 1.8 cm of the tree species observed in cluster 4, is performed at VCR index around 1500. Above 2500 through 3000 of VCR index, the species tend to respond negatively as shown in Figure 5 for *D. caudiferus*.

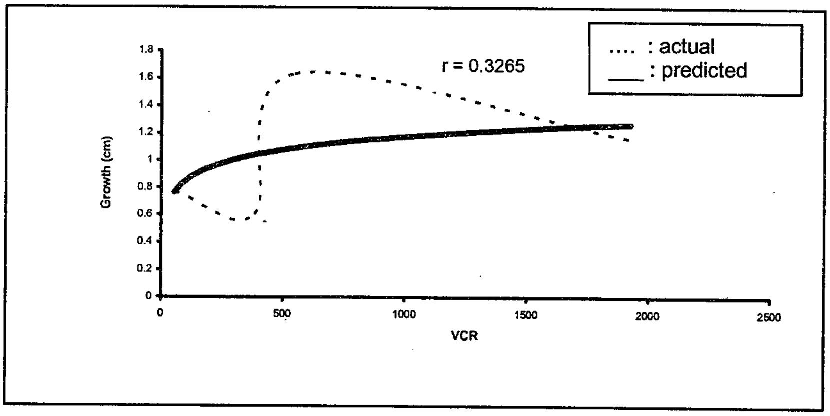

Figure 1. The relationship between the preceding year's stem diameter growth of *S. polyandra* and its crown index in Cluster 1 Pulau Laut, South Kalimantan

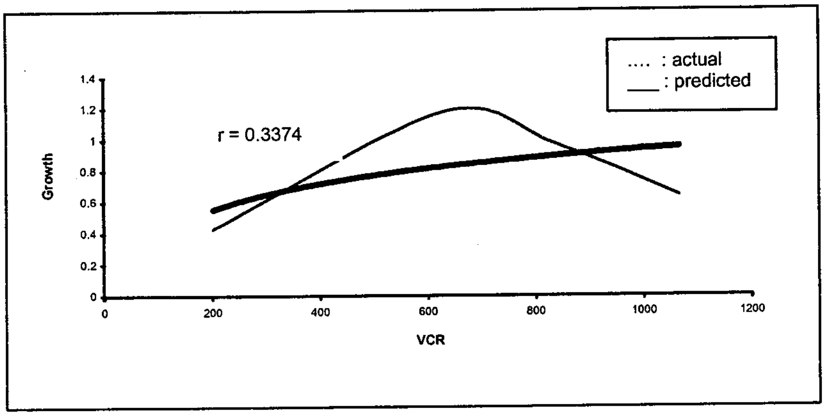

Figure 2. The relationship between the preceding year's stem diameter growth of *S.polyandra* and its crown index in Cluster 7, Pulau Laut, South Kalimantan

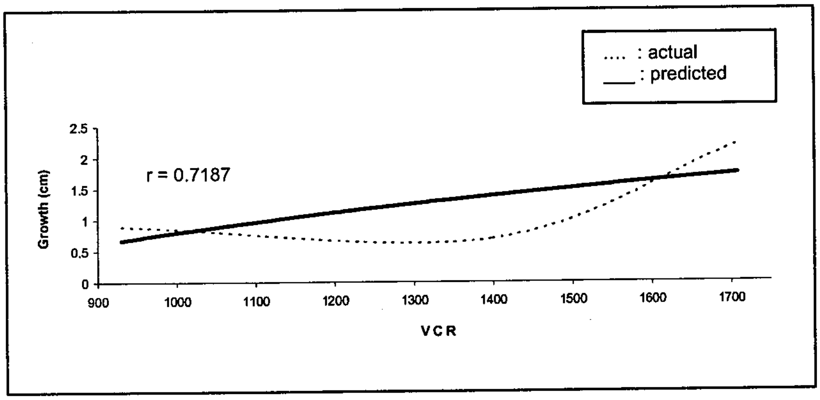

Figure 3. The relationship between the preceding year's stem diameter growth of S. johorensis and its crown index in Cluster 4, in Pulau laut, South Kalimantan

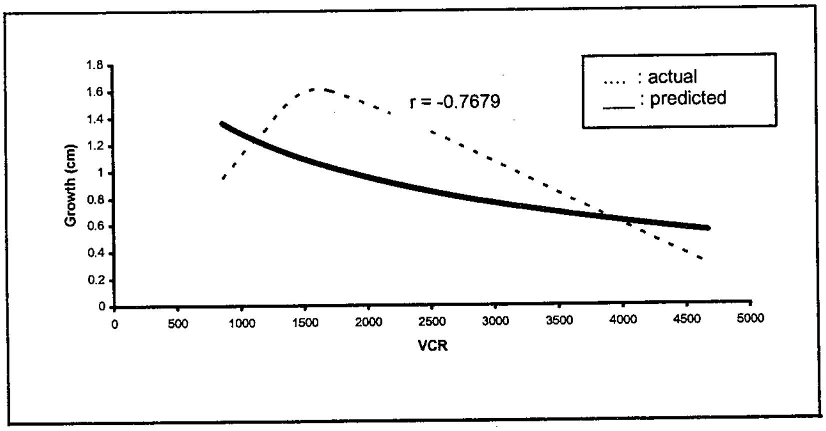

Figure 4. The relationship between the preceding year's stem diameter growth of *D. caudiferus* and its crown index in Cluster 4, Pulau Laut, South Kalimantan

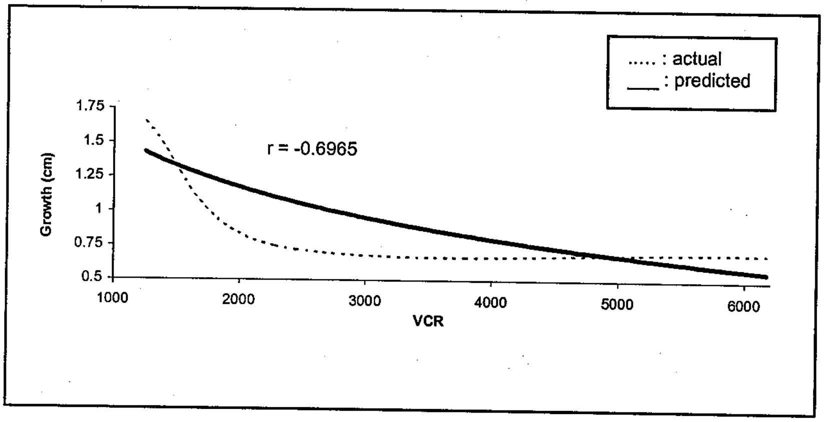

Figure 5. The relationship between the preceding year's stem diameter growth of *D. caudiferus* and its crown index in Cluster 5, Pulau Laut, South Kalimantan

3.2. Discussions

Looking at all the above figures, two phenomena are observed. The curve line of all figures indicates that there is a range of crown index showing the optimum stem diameter growth of each tree species. Looking at the specific Figures 1, 2, 4 and 5, there is a phenomenon that the range of crown index showing the optimum growth seems to depend upon tree species as well as unidentified factors (probably site conditions). Such ranges might be a reflection of growth condition. Therefore, the range is suggested for species-site and specific indicators, which is indispensable in tree health monitoring. Nevertheless, the crown condition as an indicator is doing well in terms of applicability and quite easy to detect.

The followings are some possible problems in assessing tree crown class in tropical rain forest type:

As the crown condition has been widely used as an indicator of tree health, however, to obtain better interpretative crown data, an appropriate crown assessing technique has to be well designed and appropriately modified or improved for multi layers conditions of tropical forest. One of the differences between the two forest types is the species diversity where in general it is believed that the tropical rain forest has higher than that in the temperate one. The more species growing in an unit area may show more variation on the crown layer. As it is believed that there are some differences between the two forest types (Harborne, 1988).This in particularly related to crown density and crown transparency.

When crown shape, size and position of different tree species present on a growing site, it is usually, an overlapping crowns occurs. In such condition, a problem in assessing tree crown may be occurred.

To anticipate the problem, it is suggested to select the most appropriate position from where the most part of a tree crown is feasible. More over, an assessor must has enough time to practice in order to assess it precisely.

There was, sometimes, a liana's crown covered most of a tree crown in which assessment was being conducted. The procedure of crown density assessment has not specified to cover such case. If the total crown (tree and liana) is taken as the tree crown, the collected data will be a bias one. Similar problem was also encountered in assessing crown damage.

Special attention must be given on a deciduous tree species such as *Anthocephalus chinensis* and *Tectona grandis* of which all leaves fall down annually. If crown assessment is carried out in the period of leaf fall, the crown index will not reflect the preceding year's stem diameter growth of the trees. If deciduous trees species are the majority species in the plot and crown condition is employed to evaluate the stem growth rate, crown assessment must be carried out during the foliation period , otherwise the data will be a bias.

IV. CONCLUSIONS

1. Tree crown assessment as part of Forest Health Monitoring techniques, as described by USDA Forest Service (1997) in the International version (for Indonesia) of Field Methods and Guide for Forest Health Monitoring can be applied, but needs appropriate modification, in tropical rain forest.
2. Crown condition can be used as an indicator of tropical rain forest tree health.

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APPENDICES

Table 1. Growth of *Shorea polyandra* and its crown index in different clusters in Pulau Laut, South Kalimantan (July, 1997)

Cluster	Subplot	Growth	n	Crown Indices		
				CSI	CDI	VCR
1	1	0.77	7	91.47	18.21	54.84
	2	1.16	7	3836.88	22.90	1924.53
	3	0.6	4	749.99	17.50	383.75
	4	1.63	3	1072.20	20.00	546.10
	mean	1.04	5.25	1437.64	19.65	727.31
4	1	0.8	1	3138.43	22.5	1580.46
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	1.5	1	2102.89	12.50	1057.69
	mean	1.15	1	2620.66	17.50	1319.08
5	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	--	--	--	--	--
	mean	--	--	--	--	--
6	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	--	--	--	--	--
	mean	--	--	--	--	--
7	1	0.64	7	2115.46	15.00	1065.23
	2	1.18	10	1250.46	14.75	632.39
	3	0.98	5	1648.88	14.00	831.44
	4	0.43	6	363.68	10.17	200.80
	mean	0.81	7	1344.62	13.48	682.47

Table 2. Growth of *Shorea johorensis* and its crown index in different clusters in Pulau Laut, South Kalimantan (July, 1997)

Cluster	Subplot	Growth	n	Crown Indices		
				CSI	CDI	VCR
1	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	--	--	--	--	--
	mean	--	--	--	--	--
4	1	--	--	--	--	--
	2	0.7	6	2771.38	26.25	1398.82
	3	0.9	5	1827.49	18.50	922.99
	4	2.2	4	3395.43	20.00	1707.72
	mean	1.27	5	2664.77	21.58	1343.18
5	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	1.24	8	1698.78	15.63	857.20
	mean	1.24	8	1698.78	15.63	857.20
6	1	--	--	--	--	--
	2	--	--	--	--	--
	3	0.5	1	3049.90	20	1534.95
	4	--	--	--	--	--
	mean	0.5	1	3049.90	20	1534.95
7	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	--	--	--	--	--
	mean	--	--	--	--	--

Table 3. Growth of *Dipterocarpus caudiferus* and its crown index in different clusters in Pulau Laut, South Kalimantan (July, 1997)

Cluster	Subplot	Growth	n	Crown Indices		
				CSI	CDI	VCR
1	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	--	--	--	--	--
	mean	--	--	--	--	--
4	1	0.95	2	1704.36	13.75	859.06
	2	0.30	1	9322.19	20.00	4672.00
	3	1.30	1	2366.65	12.50	1189.57
	4	1.60	1	3402.37	15.00	1710.18
	mean	1.04	1.25	4198.89	15.31	2107.70
5	1	0.75	2	4553.33	15.00	2284.17
	2	1.65	2	2468.67	18.75	1252.71
	3	0.7	1	12319.22	27.50	6173.36
	4	--	--	--	--	--
	mean	1.03	1.67	6447.07	20.47	3236.75
6	1	0.95	6	1553.91	19.58	786.74
	2	0.98	4	16082.41	25.00	8413.70
	3	0.95	2	1474.56	15.00	744.78
	4	1.04	8	2849.77	16.56	1433.17
	mean	0.98	5.33	5490.16	19.04	2844.60
7	1	--	--	--	--	--
	2	--	--	--	--	--
	3	--	--	--	--	--
	4	--	--	--	--	--
	mean	--	--	--	--	--

INFORMATION FLOW

Technical Report No. 7

Supriyanto
Simon Taka Nuhamara
Ujang Susep Irawan

ABSTRACT

To provide information on how to organize and implement the several selected indicators in Forest Health Monitoring, an information flow was purposely constructed. This step by step procedures, coupled by the method for searching any missing subplot or plot center, have been provided to equip the field crew during assessment. It is hoped that this information flow could serve as a quick reference for those interested in finding the overall idea and techniques covered in Forest Health Monitoring.

Key words: *Information flow, forest health monitoring, sustainable forest management*

I. INTRODUCTION

Forest Health monitoring, which is introduced by USDA-Forest Service is one of the methodologies that could be used to assess the current extent, status, changes, and trends using relevant indicators. The ultimate goal of following the application of the technology is to provide present condition of the nation's forest ecosystem, on a national as well as regional basis, with known statistical confidence in the estimates.

In this context, at the early step, it is considered necessary to select the relevant indicators to be tested.

Among the important things in detection monitoring activities to be considered is that all kinds of activities, should be organized in a series of packet program. Right from the preparation phase through information presentation of the field result findings obtained by means of periodical field works. Such a series of packet activities, is known as Information Flow. This is deemed necessary as to ensure the implementation efficient in terms of time allocation, cost, employee and the most important thing is to ensure the quality of the data collected. Eventually, the field activities planned will certainly provide expected optimal result.

The data obtained, will further be organized in a system called INDO-FHM Data Base Management that produced under MS-ACCESS 7.0. The data of a certain parameter are processed and / or analyzed either by using MS-ACCESS 7.0 or statistical analysis by means of SAS or Minitab Program.

II. FIELD ASSESSMENT ACTIVITIES SERIES

2.1. The First Year Measurement

The first year measurement is ideally being carried out at the same date of plot establishment. The determination of plot location should be in accordance with the assessment question addressed and / or representing different forest ecological conditions. Yet, accessibility is another aspect to be considered.

Forest health monitoring should be carried out in a series of well programmed activities starting from planning, implementation until the results achievement.

2.1.1. Field Preparation

Preparation is a very important activity prior to field execution. Fatal error in field preparation could result in reliable data recording. Some preparation activities prior to field work among others are:

Equipment and material preparation

Equipment and materials to be prepared should be suitable in conformity with the need of every indicator concerned. Table 1 indicates the main equipment and / or materials supposed to be important for different indicators.

Table 1. List of Field Equipment's and Materials Needed for Different Indicators

No.	Indicator/ Sub-indicator	Types of equipment and materials
1.	Mensuration	
	a. Stand growth	Tally sheet (1 packet), compass (1 pi's), diameter tape (1 pi's), roll meter (50 m), stationers (1 packet)
	b. Sapling growth	Tally sheet (1 packet), caliper (1 pi's), I permanent marker (1 packet), compass (1 pi's), roll meter (15 m)
	c. Understory vegetation	Label (1 packet), binocular (1pi's), polyethylene plastics (1 packet), alcohol (1 liter),
2.	Damage	Tally sheet (1 packet), stationers (1 packet), binocular (1 pi's), compass (1pi's), meter-type (15 m)
3.	Crown	
	a. Crown diameter Wide and Crown Diameter-90 (CdWd and Cd-90) , Live Crown Ratio (LCR), Foliage Transparency (FT), Crown Dieback (Dbk), Crown Density (CDn)	Tally sheet (1 packet), stationers (1 packet), (1 PI'S), roll meter (50 m), binocular
	b. Canopy density / canopy opening	Tally sheet (1 packet), stationer (1 packet), compass (1pi's), roll meter (15 m), densiometer (1pi's), flags (1 packet),
4.	Soil	Tally sheet (1 packet), stationer (1 packet), plastic clip (1 packet), ban (1pi's), dagger (1pi's), ruler (50 cm), type-meter (50 m), plastic sac (1 packet)

Table 1. (Continuation)

No.	Indicator/ Sub-indicator	Types of equipment and materials
5.	Vegetation Structure	Label (1 packet), binocular (1pi's), catapult (1pi's), big plastic sac (1 packet), alcohol (1 liter),
6.	Socio-economic and Cultural Aspect	Tally sheet (1 packet), Stationer (1 packet)

2.1.2. Field Team Organization

Field team organization is very important. Field team consists of indicator leaders according to the indicator studied, field crews and labors. Each indicator leader is assisted by field crew (s) and labors. The need of field crew and labor for each indicator leader is shown in Table 2.

Table 2. The number of field team members for each indicator studied

No.	Indicator	Indicator leader/ Field crew	Labours
1.	Mensuration a. Stand growth b. Sapling growth c. Understory vegetation	 1 person 1 person 1 person	 2 persons 2 person 2 person
2.	Damage	1 person	1 person
3.	Crown : a. Crown diameter Wide and Crown Diameter-90 (CdWd and Cd-90) , Live Crown Ratio (LCR), Foliage Transparency (FT), Crown Dieback (Dbk), Crown Density (CDn) b. Canopy density / canopy opening	 1 person 1 person	 2 persons 1 person
4.	Soil	1 person	1 person
5.	Vegetation Structure	1 person	2 person
6.	Socio-economic and Cultural Aspect	1 person	-
	TOTAL	**9 persons**	**13 persons**

In some cases, an indicator leader assists the other indicator leader during the measurement for the reason of time, budget and labor efficiencies. Every indicator leader has to prepare matrices of the basic principle of plot establishment and indicator measurement. Each indicator leader and field crew has to pass the Quality Assurance (QA) test conducted by the Expert. The use of a compass by each indicator leader for checking the tree position is necessity.

The organizational structure of FHM field team is shown in Figure 1.

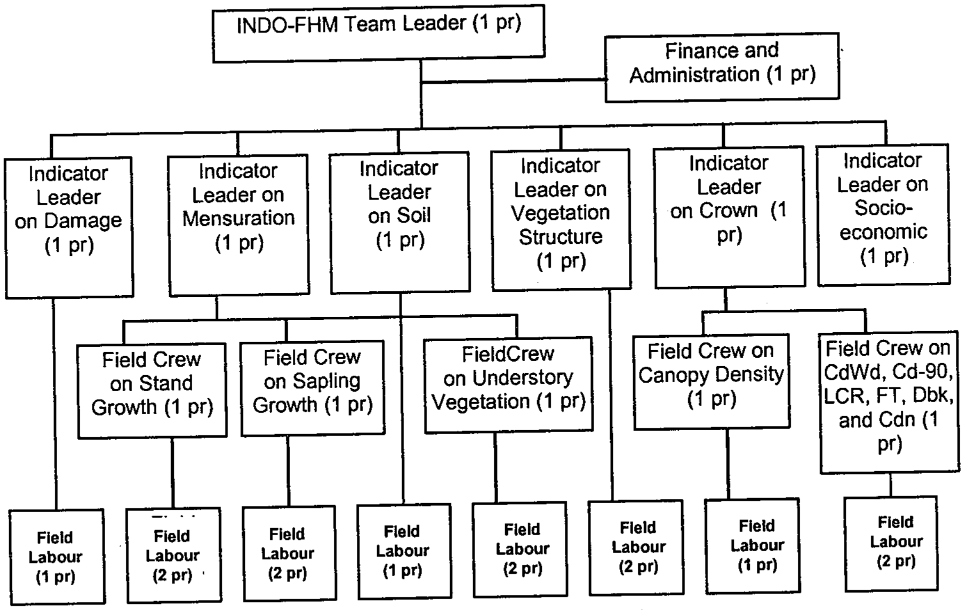

Figure 1. Structural Organization of INDO-FHM Field Team

2.1.3. Organization of Data Collection

Data collection in the proper manner is very crucial. Systematic procedures must be taken into account to arrive at high data accuracy, time, labor and financial efficiency. Team leader plays an important role in managing the field team. For efficiency and systematic, both in terms of time allocation and labor it is suggested to develop a good team-work during data collection. Field data collection scheme is presented in Figure2. It is ideally that the first data collection should be carried out following the plot establishment.

2.1.4. Data Collection to The Indicator Leader

Recorded data obtained from field measurement / observation by field crew should be handed over to the respective indicator leader. The indicator leader has the responsibility to validate and / or check the completeness and the accuracy of the data handed over to him; and if it is considered necessary they have to check the problem right away in the field.

Establishment of the Center of Sub-plot 1

The center of Sub-plot 1 is pooled from the reference point assigned at a distance, azimuth and certain altitude. In addition to that witness tree is also determined

Plot Identification

All necessary information should be recorded, covering general plot condition, plot location, plot establishment date and so on.

Establishment of the center plot of Sub-plot 2.3. and 4

1. **Determination of Sub-plot 2**
   One indicator leader / field crew lead the sub-plot establishment. To do this, they need to be assisted by two field labors. The Sub-plot establishment should be started by determining the direction at 0° at a distance of 36.6 m (center point of Sub-plot 2), 18 m (sampling point of plot 1 soil), 17. 95 m (outer most distance of annular plot), and 7.32 m (outer most distance of Sub-annular plot). Two field labors are required to place the flag and to put the mark according to the position codes of each location.
2. **Determination of Sub-plot 3**
   This Sub-plot is established at 120° azimuth at a distance and points like the Sub-plot 2 before.
3. **Determination of Sub-plot 4**
   This Sub-plot is established at 240° azimuth at a distance and points like the Sub-plot 2 before.

The indicator leader on soil with the assistance of one field labor could directly conduct the necessary works such as collecting soil sample and certain measurements following the soil sample plot that has been determined.

Tree tagging (numbering) and establishment of measurement plot

1 **Tree tagging on Sub-annular plot (radius 7. 32 m)**
   One indicator leader / field crew assisted by two field labors is assigned to determine the trees / poles, of diameter 10 CM up that are covered in Sub-annular plot. Tree tagging is started from 0° position at the nearest distance until the ferrets from the Sub-plot center.

2. **Numbering of trees at annular plot (radius 17.95 m)**
   Numbering is made like the one at the Sub-annular plot. But it is made only on tree level of DBH of 20 CM up. The order of the tree number is a continuation resulted from the Sub-plot annular numbering.

3. **Numbering of sapling at the Sub-annular plot (radius 7. 32 m)**
   This kind of activities is to be carried out following the same procedures Sub-plot lead by a field crew on sampling growth and canopy opening assisted by one field labor. Numbering at sapling level of DBH of 2.5 – 10 CM.
4. **Establishment of plot measurement and plot canopy opening**
   One field crew assisted by field labor is needed to determine the position of observation points at a distance of 7. 32 m from Sub-plot center with the position 0°, 30°, 90°, 150°, 210°, 270°, and 330°

Indicator leader/ field crew on mensuration, crown, damage, and vegetation structure with the assistance of each field labor assigned are ready to start the all planned measurement simultaneously with the tree numbering activities.

Every indicator leader is suggested to conduct their data collection at the same tree number, just for efficiency both in terms of time and labor allocation and eventually to ensure data completeness and quality.

Figure 2. INDO-FHM Field Data Collection Scheme

2.1.5. Checking and Validation of Data

Checking of the data in the camp (accommodation) is considered very important not only for completeness or accuration of the individual indicator measured, but also important for cross-checking possible missing data collection among the different indicators. As an example, the deadness of a particular tree number in the same plot should be agreeable to all field indicators (mensuration, crown, damage and so on). For such a reason, it is suggested that the FHM team should work as a solid team. All possible indicator measurements should be made on the same tree first prior to move to the next tree in the plot.

Checking and data validation is usually needed due to lock of experience of field crews. This correction is also very important for diameter measurement, sampling diameter, or crown diameter measurement. Such a low quality data will result in negative growth.

2.1.6. Insertion of data in tally-sheet

After checking and data validation, all validated data need to be completed in tally-sheet for data management. Field crews could help in doing this kind of work as part of their training and transfer of technology.

2.1.7. Data Base Management

All validated field data will then be entered into well-prepared data base computer program called INDO-FHM. All INDO-FHM Data Base management could be explained as follows:

Tally sheet is used for recording FHM field data. From September 1997, FHM D-Base has been used to manage all FHM field data with its first version runs with Window 3.1, and the second version runs under Window97. Up till now, FHM D-Base has managed 6689 recorded data from all FHM plots in Pulau Laut and Jambi, sorting, classifying and analyzing it so to become a valuable information for end users.

As a database, FHM D-Base plays an important role to prepare and provide information for the users, and also for data analysis. Input data for FHM D-Base is taken from field data collected in tally sheet. Then FHM D-Base will process the data into a useful output, such as reports or graphs.

There are some changes in tree coding regulation between tally sheet and FHM D-Base. Tree identity in FHM D-Base composed of a combination between numerical and alphabetical characters, as an example 1.5.12/PUL. The first numerical character in tree identity indicates the cluster number 1 of the tree location. The second character (5) indicate the plot number, and the third character (12) indicates the tree number in the subplot or annular plot. The alphabetical character at the end of code refers to the cluster location : PUL indicate Pulau Laut, JAM indicate Jambi, and SUM for Sumpol, South Kalimantan.

FHM D-Base®, like other database program, is used referential integrity among its tables and used query language to process raw data that have been captured in tally sheet. These referential integrity and query language will provide the users much more advantages to use this program, so that by following the instructions in this program, any user could operate this program easily. By using this program, any user could get any important information easily, such as trees growth or crown index, as well as to entry new data from tally sheet. For further statistical analyses as well as for information exchange purposes, the data stored in FHMD-base could be easily transferred into MS-Excel format to be used in such statistical program as Minitab or SAS. Reversibly, other data comes from MS-Excel format could be easily transfered into FHMD-Base.

To see the details used of FHMD-Base® or what kind of information FHMD-Base® could provide, please see Technical Report no. 3 and papers on Exploring FHMD-Base. Some rectifications of FHMD-Base are being done to improve its capability.

2.1.7.1. Data Collection

Data is commonly defined as facts finding or observations, typically about physical, biological phenomena or business transactions. More spesifically, data are results of observations of the attributes (the characteristics) of entities (such as people, places, things and events). These measurements are usually represented by symbols such as numbers and words, or by codes composed of a combination between numerical, alphabetical, and other characters (Deans and Kane, 1992).

Collecting data is a very important role in forest mensuration activity, especially if that is a repeating activity. FHM data is collected using tally sheet or portable data recorder. The quality of data depends on the quality assurance level of the data collector. It is important especially for repeated measurement, in order to reconcile the status, changes and trends that have been occurred since the previous inventory.

2.1.7.2. Tally Sheet Form

Tally sheet form is used to record field data during the forest mensuration. The FHM tally sheet form was originally developed by the USDA-FS FHM team to record all of the data on FHM field survey as shown in appendix 1. This tally sheet form includes various data, i.e. plot identification data, point level data, understory data, sketch map of plot location, sapling tree data, subplot tree data and full hectare large data, plot photographs, plot diagram with boundaries, condition class data, hectare boundary data, microplot seedling data, and site tree data.

A new type of tally sheet has been developed for the INDO-FHM Project (see Appendix 2). In this new type of tally sheet, crown condition data, tree data, and signs & symptoms data are separated into three different tallies, that can be used for four times measurement (for DBH and DBH Check), and three times for crown condition and damage. Point Number and Offset Point in this tally sheet refer to the Cluster Number and Subplot Number, which consists of two and one-digit numeric code, respectively. Tree number consists of two-digit numeric code, where Species Name consists of six character alphabetic code (in rare cases, its consist of seven characters).

Species name in this tally sheet refer to the FHM Code regulation for species name, consisting of six characters. The first three characters of the code match the first three letters of the Latin genus name, the second three characters correspond to the first three characters of the Latin species name. As an example, Shojoh is the FHM Code for *Shorea johoriensis* and Shopol for *Shorea polyandra.*

Six characters are usually enough, except in rare cases where the code for two different species is the same (e.g. *Shorea ovalis / Shorea ovata*). In this situation a seventh digit is used for further distinction. A "1" designates the species that is in alphabetical orders, a "2" indicates the species that is second. Due to this regulation, FHM Code for *Shorea ovalis* is Shoova1 and Shoova2 for *Shorea ovata.*

For the unidentified species, the code used is Sp. 1, Sp. 2, Sp. 3, etc, or used its local names with the star code before the name (*) e.g. *Medang. If only the genus name is known, the code will consist of three characters of the first three letters of the genus name and sp1, as an example Shorsp1 refer to *Shorea* sp.

Horizontal distance column consist of three-digit numeric code, used to record the horizontal distance to the nearest 0.1 m from the subplot center to the pith at the base of the site tree. The azimuth as a three digit code ranging from 001 to 360 was recorded, by viewing the base of the tree using a compass from subplot center.

DBH consist of three-digit numeric code, used to record the diameter of the trees (or poles) masured at (1.3 m) above the groundline, on the uphill side of the tree. DBH-Check used to identify any irregularities in DBH measurement positions (e.g. abnormal swellings, diseases, damage, new measurement positions, etc.). Code for DBH-Check must be "0" if there is no problem with DBH measurement, and "1" for irregular DBH measurement. Whenever code "1" is used, further explanation is required in the notes.

Crown Evaluation Measurements captured from the Crown Structures Tally are live crown ratio, crown density, crown dieback, foliage transparency, and crown diameter wide and 90^0. Each of these crown measurements has two digit numeric code, except the crown diameter (wide and 90^0) that has three digit numeric code.

Signs and Symptoms Tally are used to record any damage and catastrophic assessment. Location 1, 2, and 3 categories have one-digit numeric code, ranging from 0 to 9. Damage 1, 2, and 3 categories are recorded based on the numeric order which denotes decreasing significance from damage 01 - 31. Severity codes vary depending on the type of damage recorded. For the details of use and description of Location, Damage, and Severity Code, also for Crown Evaluation and Site Tree Code, please see *Forest Health Monitoring - Field Methods Guide (International - Indonesia 1997).*

Sapling Tally Sheet Form used to record all of the saplings (trees within the DBH between 2 and 10 cm) found in the subplot. The data in this tally include the species name, DBH (measured in cm) and LCR of the mentioned sapling.

The Densiometer Tally Sheet Form record all of the canopy-density measurement using spherical densiometer in the center, North, East, West and South position at a distance of 7.32 m from the center plot. Spherical Densiometer is specifically used to measure the estimation of density of a unit area (0.1 ha) of tree crowns in relation to the ability in penetrating light into the forest floor through the crown spaces and gaps. For the brief description on the use of Spherical Densiometer, please refer to TR 10 on Manual of the Spherical Densiometer.

2.1.7.3. Portable Data Recorder

The Portable Data Recorder (PDR) is designed by the USDA-FS FHM team as the field tool used by FHM crews to record and download data. The PDR is a rugged, small and lightweight palm top-like computer containing different data collection programs. One of the programs contained in the PDR is TALLY. All FHM forest mensuration data; crown condition classification data; damage and mortality assessment; densiometer data; soil physical characteristic; and plot location data are collected on PDR with the TALLY program which prompt the crews to enter measurements as they complete each plot. TALLY incorporates numerous list, range, and logic checks to verify the accuracy of the data. Please see *Forest Health Monitoring - PDR Guide (International Version 1997)* for detail of the use of PDR and TALLY.

Up to present now, PDR has not been used in INDO-FHM mensuration, due to some technical and administration problems. The INDO-FHM team used it only in the first training session on 1997.

2.1.8. Data Analysis

The installed data, would be easily managed for further data analysis according to each indicator. Data management using MS-ACCESS, is supported for statistical analysis using SAS Program and Minitab.

Soil sample analysis was done in Natural Product Laboratory of SEAMEO-BIOTROP

2.1.9. Data Interpretation

Result obtained from data analysis is then interpreted and conclusive information is formulated by the respective indicator leader. Based on such information, the indicator leader will be able to conclude on the status, change and possible trend of the forest condition the time.

2.1.10. Consultation

Interpretation result is prepared in consultation with the USDA Forest Service or reliable expert in the related fields. For improvement and finalization of the Technical Report a seminar on Forest Health Monitoring is organized. This Seminar was attended by various prominent scientists on the related fields.

2.1.11. Report writing

Each of the indicator leaders is responsible to prepare the final report in the form of Technical Report.

2.1.12. Dissemination of Information

Having obtained fruitful suggestions and or critics during the seminar, the technical reports are planned to be published via some accredited journals either national and / or international as a means to socialize the FHM technology.

Flow Diagram of The FHM Technology is presented in Figure 3.

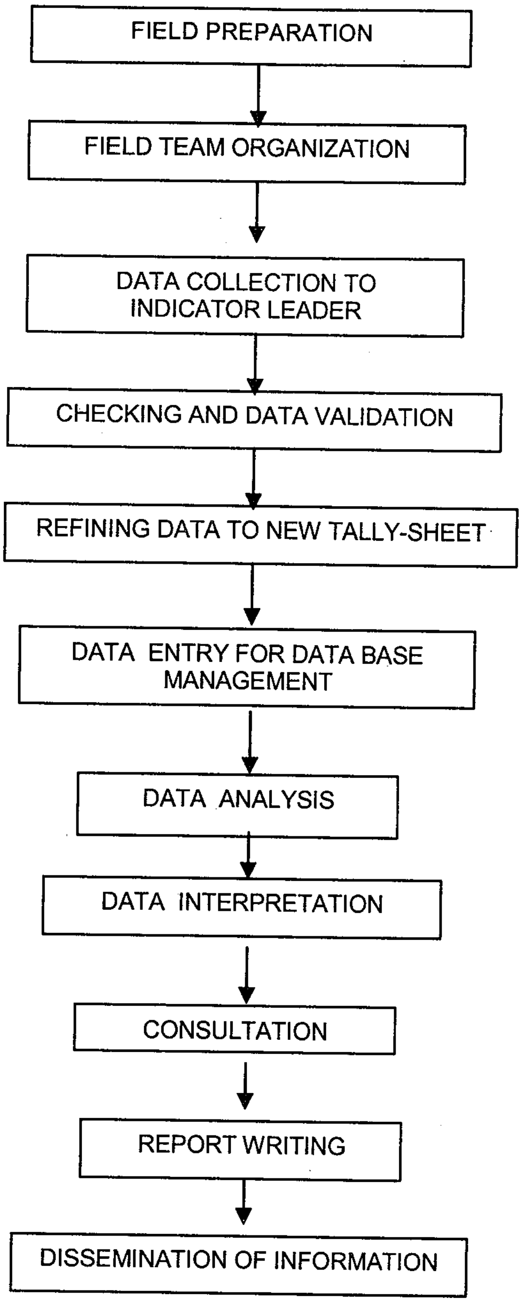

Figure 3. Information Flow

2.2. Continuation (Remeasurement) of Assessment Activities

Remeasurement is part of the FHM activities scheduled for certain time period (five years for example). Some indicators parameters need yearly assessment for example sapling growth, under story and so on.

2.2.1. Searching for Plot Center

Learning from this multi - year assessment of FHM project, it is interesting to note that the FHM technology of circular form with definite center plot is very useful one. This is very crucial, since many times our center plots were purposely or unpurposely removed away from its initial point. In this situation the remeasurement to be made is getting difficult if not impossible. This will happen to several parameters that really very much depending on center plot point such as densiometer measurement, soil sampling, rechecking tree position and so on.

The reason behind this phenomenon could be of many possibilities. Among others are forest fire, illegal encroachment , illegal cutting and other causal agents. It is imperative to develop techniques to enable to find out the center point of the plot assessed. This report is tries to introduce such a technique.

Based on the tag number

The search technique for the center sub-plot on a particular cluster could be traced following the known three tags number of standing trees.

A 180° Rotating technique

Rotating technique

of 180° can be used to fascilitate to find out the Sub-plot center. This technique can be used as follows.

- Find out trees with still intact tagging
- Pin up the tag number found with the number of the tally-sheet of the trees assessed the year before. Tagging example is shown in Figure 4.

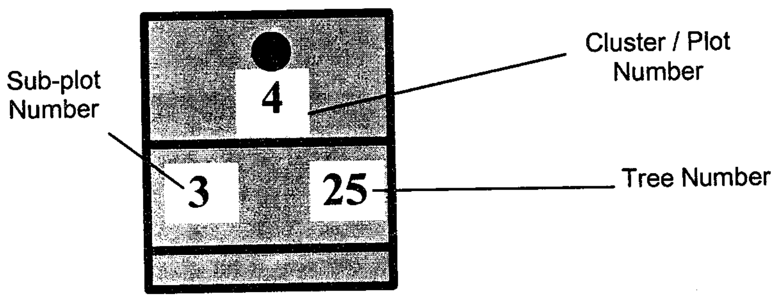

Figure 4. INDO-FHM Tagging Example

- On the tally-sheet, the following data will be found.
  - Cluster number,
  - sub-plot number,
  - the name of tree species
  - azimuth, and
  - horizontal distance
- If the tree has an azimuth of A with its horizontal distance H, the the center of the sub-plot will be: (A+ 180^0) with horizontal distance H. Example: A tree of *Shorea leprosula* with a tagging of cluster number 3, sub-plot number 2 and tree number of 20. After cross checking with the tally-sheet, the last year measurement of the tree concerned was at azimuth of 50° and its horizontal distance of 6,32 m. Then the center of the plot should be at the position: 50° + 180° = 230° with a horizontal distance of 6,32 m from the tree (Figure 2)
- If **(A + 180°) > 360°**, then subtract summation result with 360^0 (one rotation). Example: If a tree is in azimuth of 240^0 with horizontal distance of 7,56 m, then the center plot position is: 240° + 180° = **420°** = 420° – 360^0 = 60°. The conclusion is that the center plot laid on an azimuth of 60^0 with horizontal distance of 7.56 m from the tree used for verifying.
- To make this technique become more familiar, repeat the procedure using several tree with known tag.
- This technique is shown in Figure 5 below.:

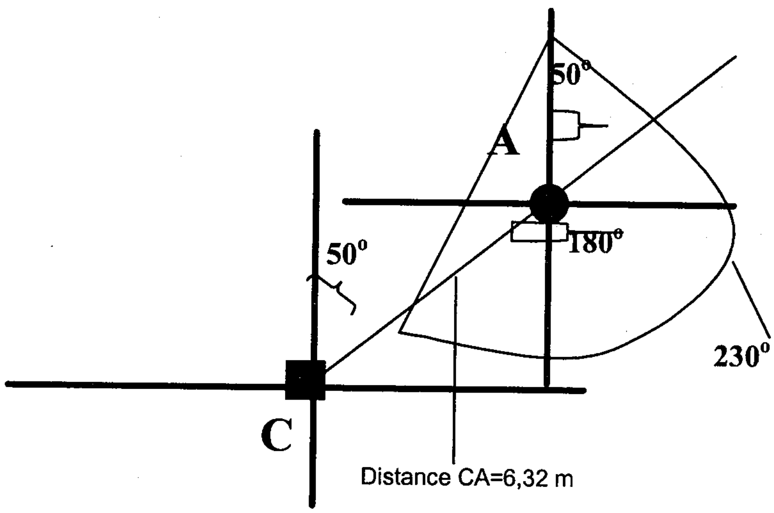

Figure 5. Rotating technique 180^0.C = center of sub-plot, A = Tree species A

Tangent-line Circular Technique

Learning from the rotating technique, to find out the center of the sub-plot, it is also good to continue with the tangent-line circular technique, Steps developed from the previous technique are only applicable to three trees having recognized tagging as follows:

- Find out three trees with recognized tagging
- Apply the rotating technique as described earlier
- Pull line (say with plastic rope from one of the tree in a direction which has been rotated 180^0 at a distance according to the figure shown in the tally sheet of the last measurement
- Repeat the procedure for the two trees or more that have recognized tagging
- Some circular lines will produce inter tangent-line at a particular point
- This point of tangent is the center of the sub-plot in search.

Figure 6 showing this technique

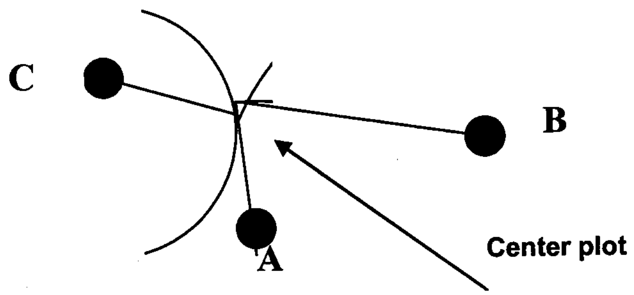

Figure 6. Position of the sub-plot at the tangent-line point A,B,C the tree species having recognized tagging

2.2.2. Finding Another Center Sub-plot

In the case a center of Sub-plot has been recognized , then the aim to go to another Sub-plot center could be traced by determining the direction and the horizon distance. Having the estimation on the distance and the posisition of a particular sub-plot, it is expected to find several tagged trees search. After those tagging are found, then the search for the other sub-plot center could be traced following the rotating technique. And the tangent line technique. Recapitulation of the position and the horizontal distance are presented in Table 3.

Table 3. Position and Horizontal Distance Inter-plot Center

Known center plot	Center plot addressed	Azimuth position (°)	Horizontal distance to the center plot (m)
1	2	0	± 36,6
	3	120	± 36,6
	4	240	± 36,6
2	1	180	± 36,6
	3	150	± 54.9
	4	210	± 54.9
3	1	300	± 36.6
	2	330	± 54.9
	4	270	± 54.9
4	1	60	± 36.6
	2	30	± 54.9
	3	90	± 54.9

The azimuth position and the horizontal distance described on Table 3 is shown in Figure 7.

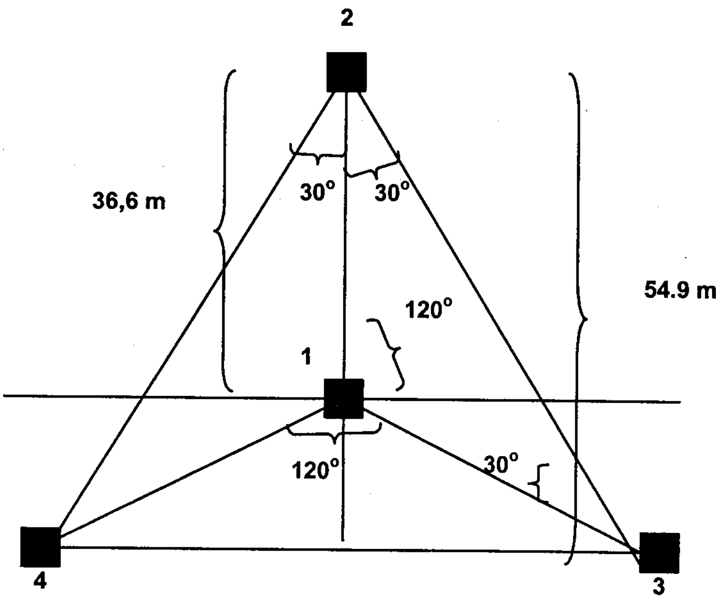

Figure 7. The center plot seen from different other center plot

2.2. 3. Remeasurement

After finding the center of the cluster, remeasurement can be carried out as has been described. The flow of activities is the same as has been made for the first measurement.

ACKNOWLEDGEMENT

This Technical Report No. 7 on the **Information Flow** has been prepared to fulfill Objective 3 point 4.5 and 4.7 of the Work-plan of ITTO Project PD 16/95 Rev. 2 (F) : Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest.

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SOIL INDICATOR : "PRESENT STATUS OF SITE QUALITY"

Technical Report No. 8

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ABSTRACT

This report discusses the present status of the soil indicator at both plots sites, Pulau Laut, South Kalimantan, and Jambi, Sumatera. The physical and chemical properties of soil are presented covering both study areas. Some soil properties could be used as indicators for the growth of certain trees. From the soil point of view, erosion, nutrients, compaction, toxic and carbon are among the parameters used in assessing the site index.

Key words: *soil indicator, forest health monitoring, Pulau Laut, Jambi*

I. INTRODUCTION

Soil, as a source of nutrients and as a natural medium of trees roots, has a significant effect on plant growth. Soils are extremely reactive, both chemically and biologically. They have the valuable capacity to degrade, decompose, or immobilize a large array of substances. Soil is a major reservoir of carbon and nitrogen in terrestrial ecosystem, therefore soil plays a fundamental role in the cycling of green house gases.

The National Research Council Reports (EMAP, 1995) recommended that : whether a range land is health at risk or unhealthy should be based on the evaluation of three criteria: degree of soil stability and watershed function, integrity of nutrient cycles and energy flows, and presence of functioning recovery mechanisms. They concluded that soil is a key element in the health of range land.

The soil stability is influenced by erosion by water, loss of nutrients, acidification, compactions, etc. The changed soil status will influence the growth of plants; therefore, in forest health monitoring, the soil measurements are intended to assess soil status in relation to these possible causes of instability and degradation.

In order to fulfill the objective, organic surface layer and soil in the A horizon and subsoil were analyzed.

II. MATERIALS AND METHODS

2.1. Field measurement

The location of the sampling points are the same as the plots for other FHM indicators. See technical report No. 1 on Plot Establishment. See also figure 1 and 2 of this report for the location of Soil sampling holes and Soil sampling visit schedule respectively.

The equipment and supplies, as well as measuring procedures, are all adapted from the FHM manual published by The US Environmental Protection Agency, Corvelis, OR.

Field measurement consists of:

1. Thickness of forest floor
2. Thickness of A horizon
3. Depth of subsoil
4. Texture of layers sampled

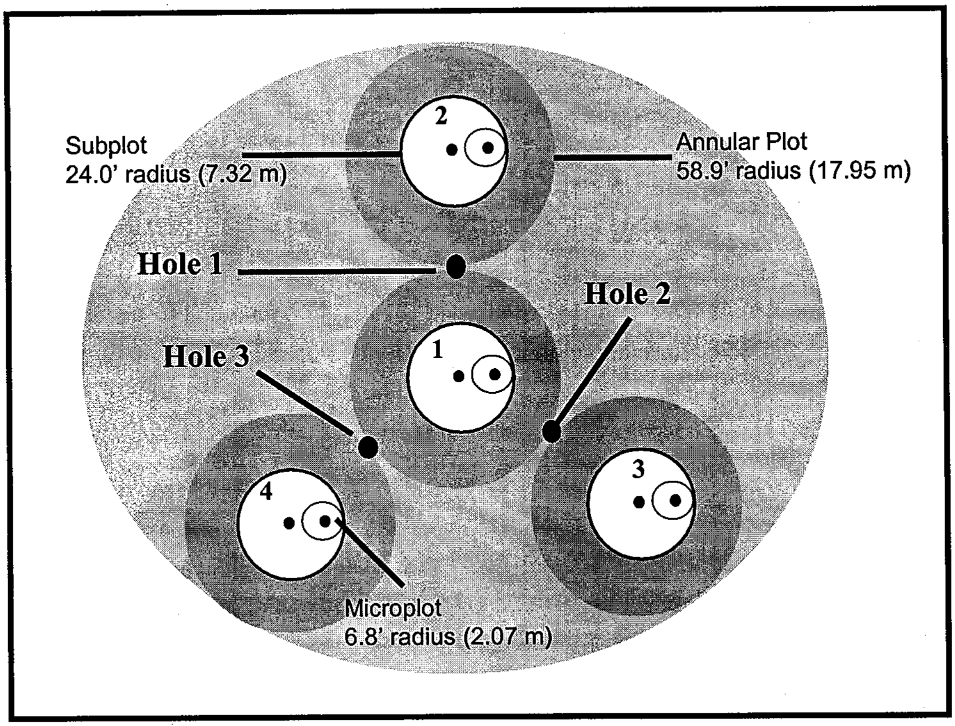

Figure 1. Location of soil sampling holes

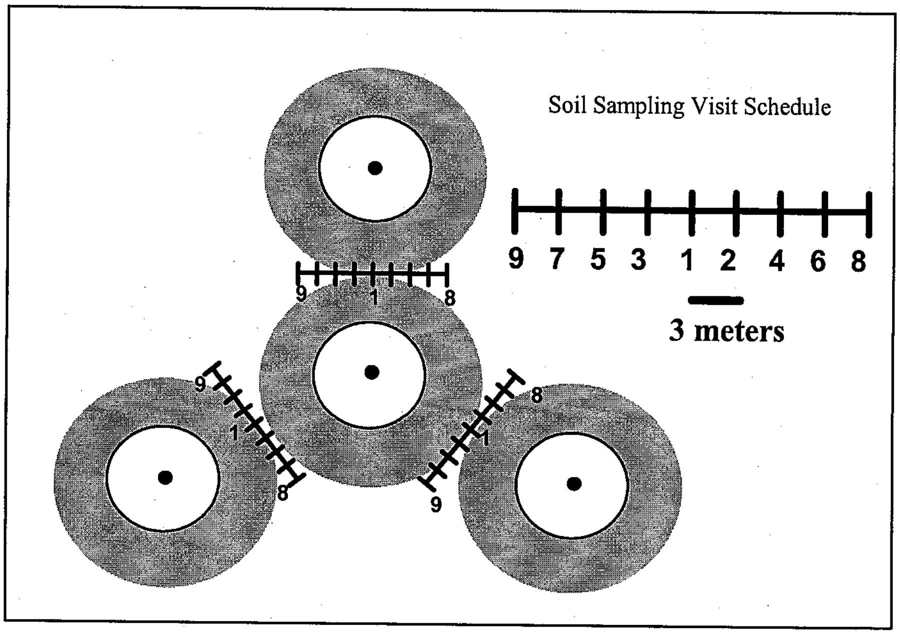

Figure 2. Soil sampling visit schedule

For soil analyses, the following steps were made.

2.1.1. Sampling collection and analyses

The Organic surface layers are sampled at only one point on each plot. Mineral soil samples are taken from three points and composite into one sample for analysis. Locate the three points using the following procedures :

- From the center of sub plot 1 of the Forest Health Monitoring (FHM) plots, measure 18 m due North, 18 m on an azimuth of 120 degrees, and 18 m on an azimuth of 240 degrees these are considered as soil sampling point 1, 2 and 3, respectively.
- The organic soil surfaces (entire O horizon) within the inner surface of the frame (0.1018 m^2) sampled in two a pre - labeled 8 litter sample bag. Measure the average thickness of the O horizon to the nearest centimeter at four points on the outer perimeter of sample area, north, east, south and west part.

The mineral surface layer was taken at the soil surface (A horizon) and the subsoil's (10 cm under the boundary line of A horizon) with the sample approximately 150 cc each at sampling points 1, 2 and 3. The samples from the same layers were composite. The texture of each layer was estimated.

2.1.2. Laboratory Analyses

For mineral soil analyses, the following elements were determined :

1. pH in water and 0.01 M $CaCl_2$
2. Total Organic Carbon
3. Total Nitrogen
4. Exchangeable Ca
5. Exchangeable Mg
6. Exchangeable K
7. Bray I Phosphorous

For organic layers, the following elements were determined:

1. Total Organic Carbon
2. Total Nitrogen
3. Present organic matter (loss on ignition)
4. Weight of fresh and dry organic soil surface (in gr./0.1018 m^2 or 0.0982 ton/ha).

III. RESULTS AND DISCUSSIONS

3.1. Field Measurements

The result of the field measurements in Jambi Province and Pulau Laut South Kalimantan Province are shown in Table 1 and 2, respectively..

Table 1. Soil Characteristics of the FHM Plots at PT. Asialog, Jambi

Location / Plot Number	Thickness (Cm)			Texture	Litter Weight (ton/ha)	
	O horizon	A horizon	Subsoil		Fresh	Dry
Jambi:						
Plot 1					8,515	7,214
• O 1	1.25	-	-	-		
• A 1	-	3.63	-	clay loam		
• B 1	-	-	10	clay loam		
Plot 2					7,650	6,134
• O 2	1.25	-	-	-		
• A 2	-	3.5	-	sandy loam		
• B 2	-	-	10	sandy loam		

Table 2. Soil Characteristics of the FHM Plots at PT INHUTANI II, Pulau Laut, South Kalimantan

Location / Plot Number	Thickness (cm)			Texture	Litter Weight (ton/ha)	
	O horizon	A horizon	Subsoil		Fresh	Dry
Pulau Laut:						
Plot 1					8.461	7.638
• O 1	1.7	-	-			
• A 1	-	1.8	-	loamy		
• B 1	-	-	15.7	clayey		
Plot 2					7.234	4.666
• O 2	0.9	-	-			
• A 2	-	1.2	-	loamy		
• B 2	-	-	7.5	clayey		
Plot 3					5.074	4.719
• O 3	0.4	-	-			
• A 3	-	0.8	-	loamy		
• B 3	-	-	10.2	clayey		
Plot 4					7.414	6.815
• O 4	0.4	-	-			
• A 4	-	0.4	-	loamy		
• B 4	-	-	7.7	clayey		
Plot 5					6.596	5.404
• O 5	1.0	-	-			
• A 5	-	0.3	-	loamy		
• B 5	-	-	13.5	clayey		
Plot 6					4.939	3.621
• O 6	1.3	-	-			
• A 6	-	0.4	-	loamy		
• B 6	-	-	14.7	clayey		
Plot 7					4.033	3.874
• O 7	0.9	-	-			
• A 7	-	4.0	-	loamy		
• B 7	-	-	14.2	clayey		

3.2. Laboratory Results

The present status of the soil in the FHM site has been analyzed at BIOTROP Laboratory. Result of the chemical analysis of organic layer at PT Asialog, Jambi are presented in Table 3. Result of the chemical analysis of the soil samples from two FHM plots at PT Asialog, Jambi are presented in Table 4.

Table 3. Soil Analysis of Organic Layer at PT Asialog, Jambi

No.	Organic Layer	N Tot	C. Organic
1.	O1	0.66	6.91
2.	O2	1.17	22.58

Table 4. Soil Chemical Analysis of Two FHM Plots at Asialog, Jambi

Parameter	Unit	O1	A1	B1	O2	A2	B2
pH (1:1) H2O	-	4.6	4.4	4.0	4.0	4.8	4.8
KCl	-	3.8	3.7	3.4	3.2	4.0	4.1
LOI (Loss on Ignitation)	%	72.95	-	27.96	36.01	-	-
C Organic (Walkey & Black)	%	6.91	1.52	10.15	22.58	1.70	11.78
N total (Kjelldahl)	%	0.66	0.19	0.72	1.17	0.20	0.70
C/N	-	10.5	8.0	14.1	19.3	8.5	16.8
Available P (Bray I)	ppm	53.8	33.7	73.5	55.4	33.7	46.4
Exchangeable base N NH4O Ac pH 7.0							
Ca	meq/ 100g	0.42	0.33	0.66	0.97	0.09	0.21
Mg	meq/ 100g	1.00	0.23	1.37	3.13	0.06	1.15
K	meq/ 100g	0.43	0.20	0.49	0.55	0.07	0.33
Na	meq/ 100g	0.39	0.26	0.32	0.23	0.07	0.10
Total Base	meq/ 100g	2.24	1.02	2.84	4.88	0.29	1.79
Cation exchange capacity	meq/ 100g	33.5	8.8	29.4	33.6	3.2	19.2
Saturation base	%	6.7	11.6	9.7	14.5	9.2	9.3
Exchangeable Al/ H N KCl							
Al^{+++}	meq/ 100g	0.23	0.34	0.26	0.32	0.20	0.14
H^{+}	meq/ 100g	0.12	0.18	0.14	0.24	0.12	0.08
Texture							
Sand	%	-	33.6	-	-	57.04	49.88
Silt	%	-	34.29	-	-	24.18	32.38
Clay	%	-	32.11	-	-	18.78	17.74

The important soil chemical properties is summarized as follows :

1. The pH (H_2O) of samples from all locations are acid, ranging from 4.0 - 4.8. The pH (1:1) KCl is always lower compared to pH (H2O). It means that it has been extremely weathered so that the mineralis dominated by kaolonite.
2. The C organic is low at A 1 and A 2. and high at B 1 and B 2. The low C organic at A 1 and A 2 maybe due to the effect of soil erosion and decomposition, where some of these areas are being used as path of gold mining squatters.
3. The N total is low at A 1 and A 2., high at B 1 and B 2. The low N total at A 1 and A 2 may be due to the effect of leaching.
4. The C/N ratio is low at A 1, and A2 and medium at B1 and high at B2..
5. The available P is very low at A1, A 2, and B2 and low at B1. The low content of P may be caused by the low content of P in parent material or due to erosion process.
6. The cation exchange capacity is very low at A 1and A 2 and moderate at B 2 and high at B 1. The low value of CEC indicated that the soil has medium texture and the organic matter is low.
7. The base saturation for all horizon are very low as the cause of the low content of most bases as the result of extensivelly soil weathering.
8. Exchangeable Al^{+++} at all horizon is very low. It means that no indication of aluminum toxicity is present in the plant.
9. The texture of A 1 is clay loam and A 2 and B2 are sandy loam.

Chemical analysis of the organic surface from PT.INHUTANI II Pulau Laut is shown in Table 5 and the soil chemical analysis of the organic soil surface from PT INHUTANI II Pulau Laut is shown in Table 6.

Table 5. Soil Analysis of Organic Layer at PT INHUTANI II, Pulau Laut

No.	Organic layer	Organic Matter (%)	N-Total (%)	C-Organic (%)
1	O I	82.80	2.64	35.6
2	OII	81.55	2.95	35.82
3	OIII	76.22	3.46	33.6
4	OIV	71.14	3.36	33.05
5	OV	74.97	3.31	31.23
6	OVI	75.82	3.00	37.37
7	OVII	80.13	3.05	28.48

Table 6. Soil Chemical Analysis of Seven FHM Plots at PT INHUTANI II, Pulau Laut

No	Hori-zon	pH H_2O	pH $CaCl_2$ 0,01 M	N - Total (%)	C-Organic (%)	P (ppm)	K (me/ 100g)	Ca (me/ 100g)	Mg (me/ 100 g)
1	A I	7.1	6.9	0.69	4.70	31.11	0.89	24.83	9.98
2	B I	7.0	6.1	0.61	4.10	07.34	0.98	12.69	5.17
3	A II	7.4	7.1	0.82	5.40	44.68	0.93	34.69	7.81
4	B II	7.0	6.4	0.50	3.50	28.12	0.54	20.95	3.28
5	A III	6.5	5.0	0.67	4.45	24.60	0.96	20.19	6.58
6	B III	5.2	5.6	0.25	1.70	25.42	0.24	3.26	1.54
7	AIV	6.7	4.0	0.30	2.00	20.40	0.42	9.19	2.59
8	B IV	5.3	5.4	0.16	1.15	2.47	0.14		1.03
9	A V	6.5	5.4	0.77	4.35	12.65	1.17	9.80	5.68
10	B V	4.5	3.5	0.16	1.05	20.61	0.40	0.92	0.93
11	A VI	6.9	5.8	0.52	3.40	10.99	0.66	6.18	3.64
12	B VI	4.6	3.6	0.14	1.00	18.80	0.16	1.37	0.65
13	AVII	7.3	6.4	0.67	3.85	42.96	1.07	28.19	10.09
14	B VII	6.3	5.1	0.18	1.15	24.04	0.60	7.80	4.21

The important soil chemical properties is summarized as follows :

1. The organic matter of surface layers more or less the same, ranging from 71.14 - 82.80%. The N total and C organic from all plots are also almost the same, ranging from 1.33 - 3.40% for N total and 28.48 - 40.76 for C organic. It meas that the variation of tree species is little.
2. The pH (H_2O), of most plots are neutral, and acid soil were found at sub-soil of plots3, 4, 5, and 6 and moderately acid was found at sub-soil of plot 7. The acid reaction in most sub-soil is caused by acid parent material.
3. The pH ($CaCl_2$) extraction method is almost lower than pH (H_2O) extraction, indicating that clay mineral of 2 : 1 or 2 : 2 type is very little.
4. The N total is low at sub-soil of plots 4, 5, 6 and 7, moderate at sub-soil of plot 3 and high in organic soil surface of plots 1, 2, 3, 4, 5, 6 and at sub-soil of plots 1 and 2. The high content of A layer is influenced by species and at B layer caused by the ability of N fixation of the roud.
5. The C organic is low at sub soil of plots 3, 4, 5, 6 and 7; moderate at organic soil surface of plot 4 and high on organic soil surface of plots 1, 2, 3, 5, 6, and 7. The lower C organic at sub-soil is the effect of decomposed of litter at the soil surface is more intensive.
6. The available P is very low at all horizon. It means the present material which bearing P type is very low.

7. The K content is high at organic soil surface of plots 1, 2, 3, 4, 5, 6, and 7 and sub soil of plots 1, 2, 4, and 7; moderate at sub soil of plot 5 and low at sub soil of plots 3, and 6. The high content of K at the A horizon indicate low leaching process in the site.
8. The Ca content is high at organic soil surface of plots 1, 2, 3, and 7 and sub-soil of plots 1 and 2; medium at sub-soil of plots 3, 6, and 7 and organic soil surface of plots 4, 5, 6, and low at the sub soil of plots 5 and 6 and organic soil surface of plots 5 and 6. The high Ca content is an indicator of the low erosion process and recycling process by plants.
9. The Mg content is high at organic soil surface of plots 1, 2, 3, 5, 6, and 7 and sub-soil of plots 1, 2, and 7; moderate at sub-soil plots 3, 4, 5, and 6 and organic soil surface of plot 4. It means that the parent material of the soil has a high content of Mg and has a recycling process of Mg through letter of plan.

IV. SOIL INDICATOR AND SOIL QUALITY

Some soil properties could be used as an indicator for the growth of a certain species. The soil properties are acidity, nutrient content, texture and depth of soil. The other factor like geology, topography, rainfall and air temperature also influence the growth of the plant. Considering plant requirements, land suitability for a certain species can be decided. Classification of land suitability is based on the important factors affecting tree growth.

Site quality gives the expected yield of each species under good management practices. Generally, measures of site quality have been based on three procedures: plant indicators, physical environment factors, and stand variables. Plant indicators and stand variables are direct indicators of forest productivity. The most direct indicators of site productivity are stand parameters such as volume, height, and diameter. Height of dominant and co-dominant trees independent has been found to be most practicable, consistent, and generally useful for site determination. In recent years, potential basal area growth is proposed as a criterion to indicate the site quality index.

When site quality is used, as determined by tree height correlated with soil properties, then soil information can be used as measure of site quality when trees are absent.

Since the growth data of trees in both sites of Pulau Laut and Jambi are not available, the site quality for the tree species in the plot area cannot be decided accurately. In general, the performance of trees in both sites indicate that site quality is good for the trees at present.

To know the accurate site quality of the soil in both sites, measurement of height, diameter and potential basal area growth for each species is needed.

Site quality or site index is a measure addressed to determine the ability of the site, especially the soil, to support growth (productivity) of certain tree species.

From the soil point of view, erosion, nutrients, compaction, toxin and carbon are among the core indicators/ verifiers in assessing site index.

In soil erosion, the most important factor is the amount of bare, exposed soil on the plot. This is suggested to be measured in future measurements.

The nutrient status in natural tropical forest is theoretically low as compared to soil under normal agricultural crops especially in Java. This is postulated or theorized by Odum, 1971. Yet, with the presence and/ or role of mycorhiza in natural tropical forest soil, its biogeochemical cycle is very efficient. In fact, very rare, if not at all, the role of mycorrhiza in site index has been properly considered. Data in Tables 1,2,3,4 and 5 indicate common physical and chemical properties of tropical forest soils. High percentage on organic matter in different soil layers both in Jambi and Pulau Laut ensures and positively affect the vitality of forest ecosystem. Total nitrogen for organic layers, and total nitrogen, plant available (Bray I) phosphorous and exchangeable basis (calcium, magnesium and potasium) for mineral soil layers as indicated in Jambi and Pulau Laut are of conducive status for forest ecosystem health.

The physical ability of roots to grow and access nutrients, water and oxygen from the soil is depend on soil texture and structure. Therefore, depth of litter, soil organic matter and soil texture is basically related to site quality.

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CROWN INDICATORS :
" PRESENT STATUS OF CANOPY STRUCTURE AND DENSITY "

Technical Report No. 9

Supriyanto
Kasno

ABSTRACT

The size and shape of a crown are considered as crown indicators. Among the measurable parameter of crown indicators are crown size, live crown ratio, crown density, crown dieback, foliage transparency, and canopy density. This report provides general information on each of the crown structure, parameters and the measurement procedures. The present status of trees crown structure, crown parameters, and canopy density on the FHM demonstration plot established in Jambi, Sumatera and Pulau Laut, Kalimantan were measured. The result showed that higher crown density caused the occurrence of lesser seedlings number. The method of assessing the crown indicator is proven to be applicable in Indonesian Tropical Rain Forest.

Key words : *Crown size, crown shape, crown structure, canopy density*

I. INTRODUCTION

Through time all growing trees and other plants undergo a change especially in size and in most cases in shape. There are various factors affecting the size and shape. Every single plant species has its own typical form of crown. The specific architecture of crown is affected by genetic factor (Oldeman, 1978). However, it is more common that plants growing in a community rather than in a singly. Therefore the crown developments are affected by the environmental factors. The information are very important for the silvicultural treatment of the tropical rain forest to achieve the sustainable forest management system (Lamprech, 1989).

When plants growing in a community, both size and shape of crown much depend on physiological and various environmental factors such as age, water, nutrient and light availability from time to time (Develin and Witham, 1983). It is a fact such external factors tend to change from time to time. The size and condition of a crown is then called as "crown indicators". Therefore, crown condition is the result of plant's response to the previous environmental factors. The canopy density affects the seedling germination, seedling and pole developments.

A system has been developed by the Forest Service of USDA (Tallent-Halsell, 1996) to evaluate the feedback of forest trees to the previous and on going external factors. Various parameters are measured to identify crown indicator. The measurable parameters of crown indicator are as follows:

1. crown size
2. live crown ratio
3. crown density and canopy density
4. crown dieback, and
5. foliage transparency

These parameters will be periodically measured during 1996-2000. At the end of this project, it is expected that the most appropriate indicators can be adopted for detection and monitoring program of Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest (INDO-FHM).

Measurement of crown indicators for that classification is one of components of forest health monitoring techniques that has been applied in United State of America and some other countries (Tallent-Halsell, 1996). The system has just been introduced, in a training level, to Indonesian scientists through the joint sponsorship of ITTO, USDA Forest Service, Ministry of Forestry of Indonesia and SEAMEO - BIOTROP.

Training and demonstration of Forest Health Monitoring plots have been established in Jambi and Pulau Laut in 1996. However, a measurement was just conducted once, therefore the possible changes of crown conditions as well as other forest health indicators can not be evaluated until the next measurement. Although, the possible applicability of the system in Indonesian tropical rain forest needs to be evaluated during the period of the project.

II. MATERIALS AND METHODS

2.1. Crown Condition

2.1.1. Crown Size

Crown size is the diameter of a circle horizontal projection of the crown. Crown size is measured on two position e.g. consist crown diameter wide and crown diameter 90°. It can be measured through the following steps:

(1) Measure it at the crown's widest point with a tape by having one observer stand under the drip line at the crown's edge, opposite an observer at the other side of the crown

(2) Make the second measurement at 90 degrees to the crown diameter at the widest point (crown diameter 90 degrees) using the some procedures. All measurements are rounded to the nearest foot (nearest 0,1 m) and both measurements are recorded in the PDR

2.1.2. Live Crown Ratio

The term living crown is the main living compact crown. A branch with small foliage apart from the upper obvious crown is excluded when the position of the crown is more than 1,5 m. Branches are only included if the basal part have more than 1 inch of diameter.

The live crown base becomes that point on the main bole perpendicular to the lowest foliage on the last branch that is included in the live crown.

The live crown base is determined by the foliage and not by the point where branch intersects with the main bole.

The live crown ratio is the measured by the following steps:

1) To be able to measures a crew steps back about 1/2 to 1 tree length from the base of the tree and move sideways at least 10 ft (3 m) to obtain a good view of the crown.
2) From the above position a crew estimates carefully the length of the living crown, say 5 m.
3) By some ways the crew estimates the total height of the tree, say 12 m.
4) Live crown ratio is 5:12 or about 40%. A clinometer can also be used for estimating the length of live crown as well as the total tree height.
5) Live crown ratio 5:12 = 0.41 but the recorded live crown ratio is 40% instead of 41%
6) Live crown ratio is based on 5 percent closes started from 5%, 10%, etc.

2.1.3. Crown Dieback

Crown dieback is defined as branch mortality which begins at the terminal portion of branch and proceeds toward the trunk and/or the base of the live crown. When whole branches are died in the upper crown, without obvious signs and or symptoms such as breaks or animal injury, assume that the branches died from the terminal down. Snag branches without smaller branches, 1 inch or less in diameter at base, is not considered as part of the crown. Dead branches in the lower portion of the crown are assumed to have died from competition and shading and are not considered as part of crown dieback, unless most of the branches above that point are dead. The crown base being observed should be in the same position that is used for the live crown ratio estimate. To estimate the crown dieback, the following procedure is followed:

(1). To obtain more accurate figure, it is strongly suggested that such measurement is conducted by two persons.

(2). The two persons step back on different direction about half to one tree length from the tree base and move sideways at least ten feet (3 meter) to obtain good view of the crown.

(3). Since cloudy sky may cause problem in observing the symptom, it is advisable to use binocular for better observation.

(4). The portion of crown dieback to the whole crown is based on 5 % classes starts from 5 % , 10 %, etc.

(5). If two persons have so much different estimation, the figure must be discussed to obtain the appropriate one.

2.1.4. Crown Density and Transparency

Crown density is the amount of crown branches, foliage and reproductive structures that blocks light visibility through the crown. Foliage transparency is defined as the amount of sky light feasible through the live, normally foliated portion of the crown or branches.

If crown density is high the foliage transparency will be low. Under normal range of tree crown condition, therefore, the scale of crown density and foliage transparency reverse one and each other, as shown the following scales:

Crown density Scale (%)	95	85	95	65	55	45	35	25	15	5
Foliage Transparency Scale (%)	5	15	25	35	45	55	65	75	85	95

2.2. Crown Class

Crown structure of forest stand may be classified into one of the following classes: (a) Open crown, (b) dominant crown, (c) co-dominant crown, (d) intermediate crown, and (e) overtopped crown. The following are the code and definition of each crown class. Crown class consists of 5 classes namely :

Code 1: Open crown. Trees whose crown has received full light from above and from all sides during early development and most of their life. Their crown form or shape appears to be free of influence of neighboring trees.

Code 2: Dominant. Trees with crown extending above the general level of the crown cover and receiving full light from above and partly from the sides. These trees are taller than the average trees in the stand and their crowns are well developed, but they could be somewhat crowded on the side.

Code 3: Co-dominant. Trees with crown at general level of the crown canopy. Crowns receive full light from above but little direct sunlight penetrate their sides.

Code 4: Intermediate. These are shorter than dominant and co-dominants, but their crowns extended into the canopy of co-dominant and dominant trees. As a result, intermediates usually have small crowns and are very crowded from the sides.

Code 5: Overtopped. Suppressed trees with crowns entirely below the general level of the crowns canopy that receive no direct sunlight either from above or the sides.

Crown structure classification deals with crown position among of immediate crowns of forest stand. Crown structure is not a parameter, therefore, is not measurable, but can be determined.

2.3. Canopy Density

Canopy density plays important role in the physiological process of seed germination, seedlings, saplings and poles development for forest regeneration.

The canopy density is measured using the Spherical Densiometer Model A that consists of 24 squares. Each square represents four dots that equivalent to a quarter canopy opening (Figure 1).

To obtain the actual percentage of overhead area being not occupied by canopy the total dots are multiplied by 1.04 as a correction factor. The difference between this value and 100 % is the estimation of canopy density.

Assuming each dot representing 1 % percent is considered accurate enough. Make four to eight reading per location facing to the North, East, South, and West - then record it and calculate the average value.

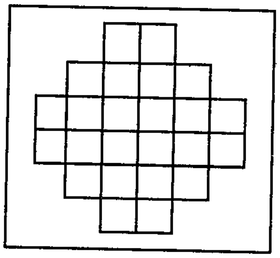

Figure 1. Square grids of the spherical densiometer, each square represents 4 % of canopy opening

2.4. Forest Sapling Vigor

Sapling vigor consists of 3 classes namely :

Code 1 : 100 to 80 % crown area with normal foliage, 1/3 or more sapling height in foliage (greater than 30 % live crown ratio), and less than 5 % dieback in the upper or outer exposed portion of the crown.

Code 2 : 79 to 21 % crown area with normal foliage

Code 3 : 20 t0 1 % crown area with normal foliage

III. RESULTS AND DISCUSSION

Demonstration plots of Forest Health Monitoring have been established in areas of forest concession managed by PT. ASIALOG, Jambi and PT. INHUTANI II, Pulau Laut, South Kalimantan. First assessment on crown indicators of plots established in Jambi and Pulau Laut were done in 1996. The first collected data of crown indicators are then called as present status until the second assessment is done.

Present status of crown indicators is presented in the following arrangement. Crown conditions of forest trees in the plots established in Jambi are presented in Table 1. Crown structure data of forest stand in FHM plots established in Jambi are presented in Figures 2 - 6. The canopy density data of forest stand in the FHM plots established in Pulau Laut are presented in Table 2. The seedling conditions are presented in Table 3 and 4.

3.1. Tree Crown Parameter

Table 1. Crown parameters of FHM plots in Jambi

Cluster	Stratum	**Crown indicators**	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Average**
1	Tree	Live crown ratio	40	40	30	40	37.50
		Crown density (%)	51.36	55.00	34.09	52.27	48.18
		Crown dieback (%)	6.81	2.50	13.63	1.81	6.18
		Foliage transp. (%)	17.72	11.25	18.00	30.72	19.42
		Crown wide (m)	4.32	7.06	14.42	22.41	12.05
		Crown 90 ° (m)	3.55	6.26	13.64	17.90	10.33
		Average crown size	**3.94**	**6.66**	**14.03**	**20.16**	**11.19**
	Pole	Live crown ratio	40	45	40.	30	38.75
2	Tree	Live crown ratio	35	40	*	*	37.50
		Crown density (%)	51.36	55.00	*	*	53.18
		Crown dieback (%)	6.81	2.50	*	*	4.65
		Foliage transp. (%)	17.72	11.25	*	*	14.48
		Crown wide (m)	4.32	7.81	*	*	6.06
		Crown 90 ° (m)	3.55	6.26	*	*	4.90
	Pole	*	*	*	*	*	

* = Data were not collected yet

Table 1 indicates that the most forest trees in Jambi plots looks to have normal crown, specifically indicated by the foliage transparency and crown density. The total score of Foliage Transparency and Crown Density nearly close to 100. Such data indicates that most crown have small gaps.

3.2. Crown Structure

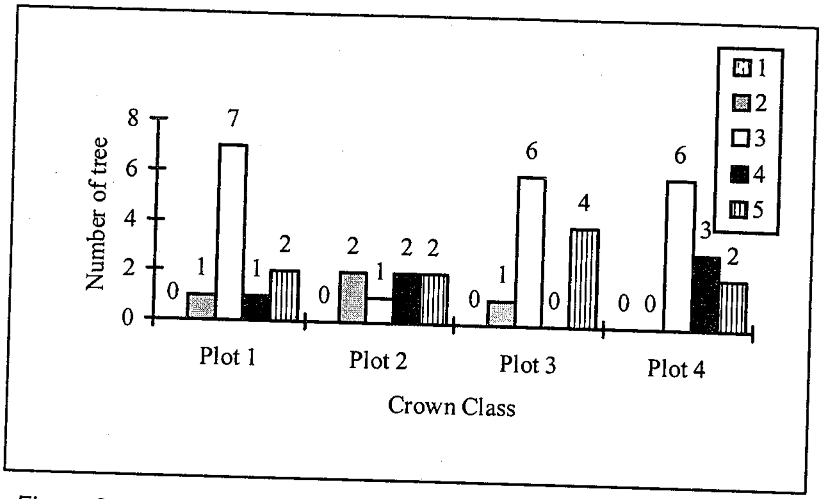

Figure 2. Tree crown class distribution of FHM Plots, Cluster 1, Jambi

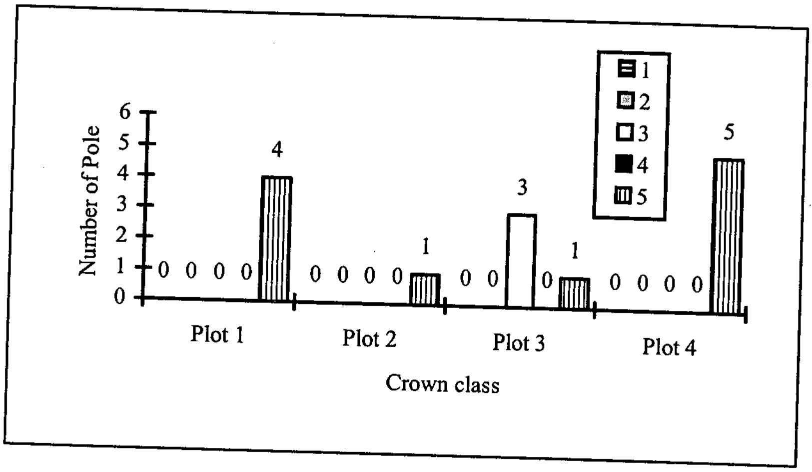

Figure 3. Pole crown class distribution of FHM Plots, Cluster 1, Jambi

Figure 2 indicates most of the plots showing a normal range of natural forest with multi trees species. In such forest type, open crown and dominant crown take small proportion while co-dominant and intermediate crowns to be the dominance. While Figure 3 showing a normal range of pole crown structure as affected by tree crown structure as presented in Figure 2. Most pole crown should be in overtopped class except if for poles grow on a gap.

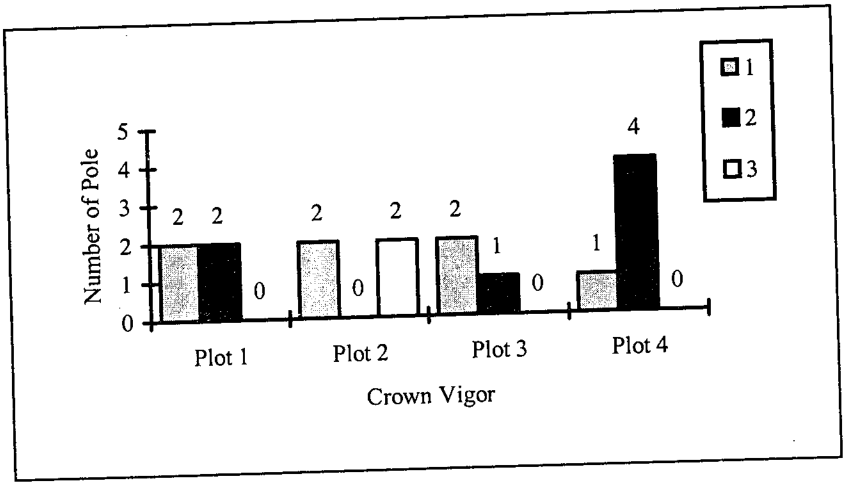

Figure 4. Pole crown vigor distribution of FHM Plots, Cluster 1, Jambi

Figure 4 shows a good pole crown vigor where there is no any poor crown in the study sites. Based on crown indicators presented in Figures 2 – 4, the forest stand of FHM plots in Jambi was under normal condition. Similar phenomenon to the above described is also shown by following Figures 5 and 6.

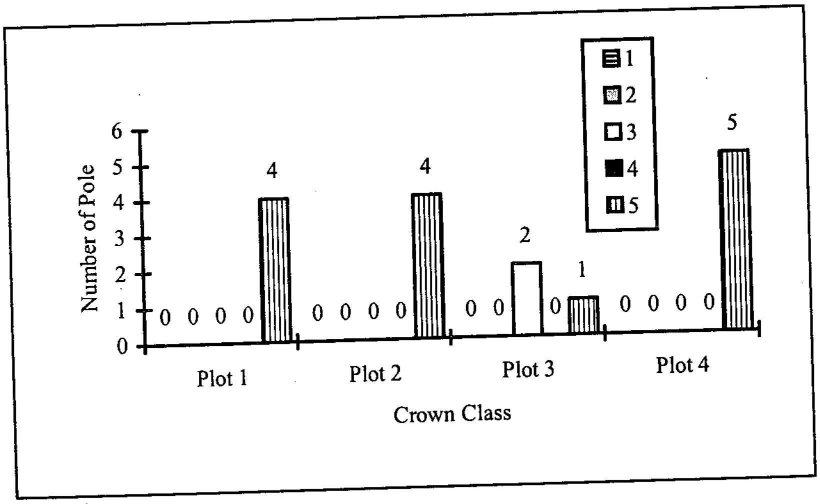

Figure 5. Pole crown class distribution of FHM Plot, Cluster 2, Jambi

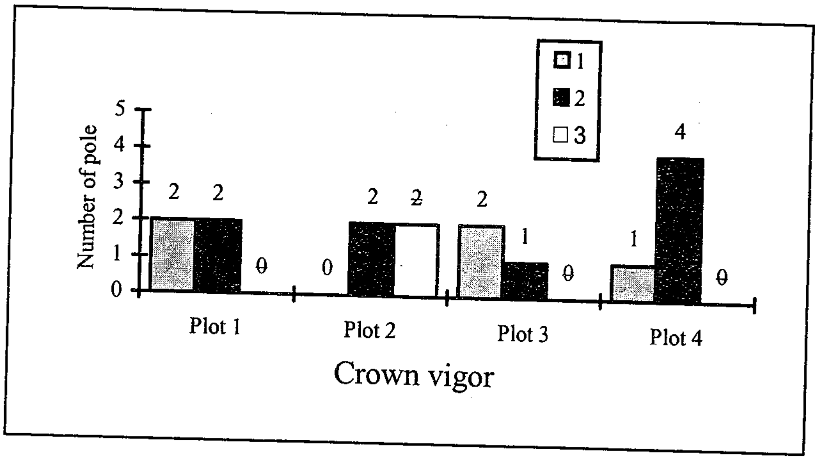

Figure 6. Pole crown vigor distribution of FHM Plots, Cluster 2, Jambi

3.3. Canopy density

Until the end of 1996, canopy density data were only collected from FHM plots in Pulau Laut (Table 3). It was shown that the canopy density / canopy closing was relatively high as the score more than 80 % in most of cluster plots. It means that the canopy opening was about 20 %.

Table 2. Canopy Density of Forest Stand of FHM Plots in Pulau Laut

Cluster	Plot	Canopy density at each point (azimuth)				Average
		0°	90°	180°	270°	
1	1	86	83	88	86	85
	2	85	89	82	75	62
	3	93	95	94	91	93
	4	91	91	93	91	91
					Average	**82.75**
2	1	83	93	94	78	87
	2	87	88	95	88	89
	3	90	81	84	89	86
	4	85	87	87	83	85
					Average	**86.75**
3	1	75	86	87	93	85
	2	88	93	91	92	91
	3	90	93	92	92	91
	4	93	92	91	89	91
					Average	**89.5**

Table 2. (Continuation)

Cluster	Plot	Canopy density at each point (azimuth)				Average
		0°	90°	180°	270°	
4	1	83	83	77	83	85
	2	82	75	60	79	78
	3	76	77	89	84	81
	4	84	83	77	76	85
					Average	**82.25**
5	1	81	87	89	86	85
	2	86	84	86	80	84
	3	76	74	81	76	78
	4	87	85	85	88	86
					Average	**83.25**
6	1	93	90	88	82	88
	2	93	91	80	85	87
	3	95	91	91	86	90
	4	91	89	88	83	87
					Average	**88.00**
7	1	87	90	93	81	87
	2	85	89	91	91	79
	3	87	93	93	94	91
	4	86	91	92	91	90
					Average	**86.75**
					Grand average	**85.61**

3.4. Seedling Condition

Table 3. Seedling Diversity and Count in FHM Micro Plot, Jambi

Cluster	Local Name	Number of Seedling			
		Plot 1	Plot 2	Plot 3	Plot 4
1	Asam	3	0	1	0
	Jambu	3	2	0	5
	Kempas	0	3	2	0
	Kedondong	1	0	2	4
	Kopi	0	1	0	3
	Medang	3	0	28	2
	Meranti	0	3	1	1
	Petaling	2	1	2	0
	Sirsat	0	0	1	0
	Resak	0	0	0	1`
	Total	12	10	37	16

Table 3 shows there were various species of seedling in FHM plots of cluster 1 in Jambi. In connection with Table 1, plot 3 and 4 of cluster 1 have more seedlings count even with longer crown size than plot 1 and 2. However such phenomena does not indicate that the seedlings in plot 3 and 4 are mostly light tolerant seedlings but probably due to the seed availability in the soil. Mean while Table 4 shows there were fewer diversity of seedling could be found in FHM plots in Pulau Laut and *Shorea polyandra* was the most dominant species. Although the canopy density of forest stand of FHM plots in Pulau Laut were all relatively high as presented in Table 2, but the seedling count in each plot greatly varied (Table 4). Since *S. polyandra* seedling is a light tolerant seedling, the seed availability in each plot has probably caused the seedling count was so different. Moreover, it was shown that seedling varied in vigor class. Such phenomena, probably the indication of seedling competition among the different seedling age. It was unfortunate that tree crown parameters of FHM plots in Pulau Laut has not yet been measured. If tree crown parameters has been collected, probably, the speculation in trying to know why the seedling count was so vary will be minimized.

Table 4. Seedling Condition in FHM Micro Plot, Pulau Laut

ID	Species	Cluster	Plot	Location	Con Cl	Cr Class	Cr Vgrl	Count
MS7.4.02/PUL	Shopol	7	4	Pulau Laut	3	5	2	23
MS3.2.01/PUL	Shopol	3	2	Pulau Laut	3	5	2	2
MS1.4.01/PUL	Shopol	1	4	Pulau Laut	3	5	1	23
MS3.4.01/PUL	Shopol	3	4	Pulau Laut	3	5	1	1
MS1.3.02/PUL	Shopol	1	3	Pulau Laut	3	5	3	2
MS1.3.01/PUL	Shopol	1	3	Pulau Laut	3	5	2	17
MS3.1.01/PUL	Shopol	3	1	Pulau Laut	3	5	3	1
MS2.1.01/PUL	Shopol	2	1	Pulau Laut	1	4	1	16
MS1.3.03/PUL	Shopol	1	3	Pulau Laut	3	5	1	2
MS2.1.02/PUL	Shopol	2	1	Pulau Laut	1	4	2	5
MS1.2.01/PUL	Shopol	1	2	Pulau Laut	3	5	1	7
MS2.3.01/PUL	Shopol	2	3	Pulau Laut	1	4	1	9
MS1.1.01/PUL	Shopol	1	1	Pulau Laut	3	5	2	5
MS6.3.01/PUL	Litrox	6	3	Pulau Laut	1	1	1	2
MS7.1.02/PUL	Shopol	7	1	Pulau Laut	3	5	2	24
MS2.4.01/PUL	Shopol	2	4	Pulau Laut	1	4	1	3

Table 4. (Continuation)

ID	Species	Cluster	Plot	Location	Con Cl	Cr Class	Cr Vgrl	Count
MS7.2.02/PUL	Shopol	7	2	Pulau Laut	3	5	2	7
MS5.3.01/PUL	Antcad	5	3	Pulau Laut	1	1	1	1
MS7.3.01/PUL	Shopol	7	3	Pulau Laut	3	5	3	1
MS7.2.01/PUL	Shopol	7	2	Pulau laut	3	5	3	2
MS6.3.02/PUL	Canlit	6	3	Pulau Laut	1	1	1	1
MS6.2.02/PUL	Verarb	6	2	Pulau Laut	1	1	1	2
MS7.3.02/PUL	Shopol	7	3	Pulau Laut	3	5	2	18
MS7.4.01/PUL	Shopol	7	4	Pulau Laut	3	5	3	15
MS6.2.01/PUL	Dipcau	6	2	Pulau Laut	1	1	1	2
MS7.1.01/PUL	Shopol	7	1	Pulau Laut	3	5	3	3

IV. CONCLUSIONS

1. The different number of seedling in each FHM plots looks to be the function of seed availability.
2. Crown condition in the study sites looks to be under a normal range.
3. The method in measuring crown condition, crown identification, and canopy density may be applied under Indonesian Tropical Rain Forest

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VOLUME I