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Value of Vitality Status in Monoculture and Agroforestry Planting Systems of the Community Forests

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Abstract

Vitality is a vigor value of the trees in responding to the environmental conditions. Vitality value is determined by calculating the damage location, cause of damage and damage severity. Vitality will affect to the wood quantity and wood quality. Quantitatively, the current timber production coming from community forests, especially Sengon (*Paraserianthes falcataria*) are still sufficient to meet the needs of the wood processing industries in Indonesia, but in term of quality, there are still many weaknesses on wood defects due to pest and dieses problems. Therefore, to obtain and to maximize the wood quality of timber planted by the community, the plantation should be in healthy conditions. Healthy trees are reflected in their minimum damage, where the damage could be caused by biotic and abiotic agents. Identifying the signs and symptoms of damage to trees

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provide valuable information about the condition of community forests in monoculture and in agroforestry planting system and show probable cause deviations from the expected conditions. Identifying the signs and symptoms of damage to trees provide valuable information about the condition of community forests in monoculture and in agroforestry planting system and show probable cause deviations. The trees with minimum damage conditions could explain the vitality of the community forest either in monoculture or agroforestry planting systems. This study aimed to determine the value of vitality status of community forest in monoculture and agroforestry planting systems for forest management decisions. Eight Forest Health Monitoring (FHM) cluster plots were established in monoculture community forest and eight FHM cluster plots were established in agroforestry planting system in Lampung province area. Vitality assessment of community forest monoculture and agroforestry planting system derived from the value damage index of the cluster-plot level based on FHM method; which is classified in to good, medium and poor. The results showed that the vitality status of community forest monoculture planting system are good (3 cluster-plots) and medium (5 cluster-plots); and agroforestry planting system are good (6 cluster-plots), moderate (1 cluster-plot), and poor (1 cluster-plot). It means the agroforestry planting system for Sengon is recommended to minimize the damage for having better good quality and sufficient quantity for timber production in wood-based industry.

Keywords: tree damage conditions; value of vitality status; community forest; monoculture and agroforestry planting systems.

1. Introduction

Vitality value is determined by calculating the damage location, damage type and damage severity. Vitality will affect to the wood quantity and wood quality. Different silvicultural practices may produce different plantation quality. Generally, there are three types of planting systems in community forest in Indonesia, those are monoculture, polyculture and agroforestry [1, 2, 3, 4, 5]; which depends on the wishes of farmers, market trends, government administration, land tenure, farmer's efforts, farming technologies, the ability of human resources, and the local culture. The selection of the planting system is related closely to the need of farmers for increasing the economic value and improving the ecological function for sustainable development. Sufficient quantity and good quality of community forests will contribute significantly to meet the needs of wood-working industries. [6] said that the role of community forests in supporting the supply of the timber in Indonesia today begin to be considered. It becomes a model in natural resource management which is supported by the government to support the forestry industry. The fact, the current raw material supply to wood-based industries coming from the natural forest and plantation forest are decreasing.

Quantitatively, timber production coming from community forests can meet the raw material needs by the wood processing industry in Indonesia, but in term quality, timber coming from community forest planted by monoculture and agroforestry planting system still has many weaknesses on wood defects due to some biotic and abiotic damages. Consequently, the timbers coming from community forest must be managed in sustainable way and in good health conditions for producing good wood quality. The healthy tree is if there is no interference biotic and abiotic factors [7]; and if the tree can carry out their physiological functions according to its genetic potential [8], so that the healthy condition of the tree refers to the pathological aspects and conditions of the outward appearance of the tree. Healthy trees are influenced by the damage that occurred to the tree. Damage that occurs in the tree can be caused by disease, insect pests, weeds, fire, weather, animals or from human activities [9, 10, 11]. Tree damage(s) are caused by one of these agents, either alone or in combination can significantly influenced to the health of community forests either in monoculture or in agroforestry planting system. Symptoms of damage to trees may be brief or persistent, so the decline in the quality of community forests monoculture and agroforestry planting system can be seen from the level of damage suffered by trees constituents.

Identifying the signs and symptoms of damage to trees provide valuable information about the condition of community forests in monoculture and in agroforestry planting system and show probable cause deviations from expected conditions. According to [12], the malfunction indicator acts as an early warning, providing information on sustainability, durability, productivity, and aesthetics; because all kind of damages will affect to decreasing the growth rate, loss of biomass, low canopy conditions and especially death [13]. Therefore, the tree damage condition could explain the vitality of the community forest. One way to determine the vitality of the community forest is by assessment of trees damage using Forest Health Monitoring (FHM) method [14, 15], in FHM method, condition of tree damage based on the location of the damage to the tree, the type of trees damage, and severity were inflicted; by classifying the type and extent of damage rate per individual tree.

Quantitative assessment describes the condition of tree damage and estimate category the vitality status of community forest in monoculture and agroforestry planting system. Data and information that collected is expected to create understanding and provide a basic data to determine the health condition of community forest ecosystem in monoculture and agroforestry planting system as well as the changes that occurring on it to ensure the quantity and quality of community forest in monoculture and agroforestry planting system, so that such data and information is absolutely required by the owner or manager of community forest to obtain the right decision for the implementation of community forest management system that supports the principles of sustainability [16, 17, 18].

Sengon (*Paraserianthes falcataria*) is important fast growing tree species in Java and Sumatera islands, Indonesia, especially for plywood and other wood working industry. It is commonly planted by the community in monoculture and agroforestry planting system. Unfortunately, Sengon is very susceptible to stem borer and some other defoliator insects, which cause the decrease of wood quality and tree growth. Therefore, the health status of Sengon planted in community forest must be assessed using Forest Health Monitoring techniques to provide a series of data for management decision.

The aim of this study was to determine the vitality status of Sengon community forest planted in monoculture and in agroforestry planting systems in the context of forest management decisions.

2. Materials and Methods

Research was conducted at Sengon (*Paraserianthes falcataria*) plantations located at community forest in Lampung Province, on September – October 2012. Sengon monoculture plantation amounting to 10.5 ha and

Sengon agroforestry plantation amounting to 31 ha were selected for FHM plot establishment. Forest Health Monitoring plot system was used and established in those forests. Eight (8) FHM cluster plots in monoculture and eight (8) FHM cluster plots in agroforestry plantations were established. Cluster plots number 1, 2, 5, 6, 9, 10, 13 and 14 were established in monoculture plantations and cluster plot number 3, 4, 7, 8, 11, 12, 15 and 16 were established in agroforestry plantations. The FHM cluster-plot design is shown in Figure 1.

Materials used in this study consisted of tally sheet, plastic clips, tacks, meter (50 m), ribbon feet (50 cm), GPS (*Global Positioning System*), binoculars, digital cameras, and stationery.

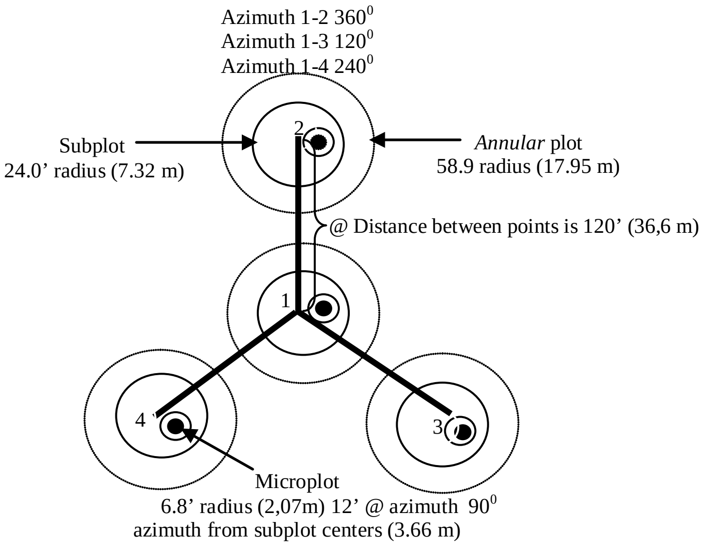

Fig. 1. FHM cluster plot design [14, 15]

Assessment of tree damage was measured on the trees located at subplot because the diameters of the trees are mostly < 20cm. The annular plots are used for measuring the tree damage at diameter >20cm. Signs and symptoms of tree damage are recorded based on the damage location which consisted of 9 positions, those are the exposed roots and ”stump”, roots and lower bole, lower bole, lower and upper bole, upper bole, crown stem, branches, buds and shoots, and foliage.

Assessments of tree damage use the code according the FHM method published by [13, 14, 15, 19] that consisted of damage location (Table 1), damage type and severity (Table 2).

Table 1. Codes of damage location

Code	Damage location
0	No damage
1	Roots (exposed) and ”stump” (12 inches (30 cm) in height from ground level)
2	Roots and lower bole
3	Lower bole (lower half on the trunk between the ”stump” and base of the live crown)
4	Lower and upper bole

Code	Damage location
5	Upper bole (upper half on 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 (> 1” at the point of attachment to the main or crown stem within the live crown area)
8	Buds and shoots (the most recent year’s growth)
9	Foliage

In certain location, the hierarchy of the damage following the code number for the probable damage type that may occur in the site [20, 21]; to meet the minimum threshold of severity for the appropriate category of the damage type (Table 2).

Table 2. Codes and type of damage and severity type according to the threshold

Code	Type of damage	Severity threshold
01	Cancer	≥ 20% of circumference at the point of occurrence
02	Conks, fruiting bodies, and other indicators of advanced decay	None, except for ≥ 20% for roots > 3 feet (0.91 m) from bole
03	Open wounds	≥ 20% of circumference at the point of occurrence
04	Resinosis or gummosis	≥ 20% of circumference at the point of occurrence
05	Broken / Cracks and stems	None / > 5’, 1.52 m in length and on at least 20% of branches
06	Nest termite	≥ 20% the point of occurrence
11	Broken bole or roots lees than 3 feet (0,91 m) from bole	none
12	Brooms on roots or bole	≥ 20% of roots
13	Broken or dead roots (beyond 3 feet (0,91 m)) from bole	≥ 20% of roots
20	Liana / Vines in the crown	≥ 20% the point of occurrence / ≥ 20% of live crown affected
21	Loss of apical dominance, dead terminal	≥ 1% crown stem
22	Broken or dead	≥ 20% of branches or shoots
23	Excessive branching or brooms within the live crown area	≥ 20% of branches or brooms
24	Damaged buds, foliage or shoots	≥ 30% of buds, foliage or shoots
25	Discolaration of foliage	≥ 30% of foliage

Code	Type of damage	Severity threshold
26*)	Gall rust	≥ 20% the point of occurrence
31	Others	none

Note: Code 26 was used to note the gall rust that eventually attack the Sengon

The tree damage consists of consecutive three codes to describe the damage location, damage type, and severity class. Tree damages records was done for a maximum in three damage locations to meet the threshold level of severity, starting from the location having the lowest code. When there are multiple damages occurred at the same location, only the most severe damage/most damage was recorded. The lower code number of damage type, the priority is higher. Data of tree damage condition assessment in each cluster-plot were recorded in tree damage tally sheet conditions (Table 3).

Table 3. Tally sheet of tree damage conditions

FHM ID	Species	Damage codes								
	ID	DgL1	DgT1	Svrt1	DgL2	DgT2	Svrt2	DgL3	DgT3	Svrt3
01.1.01/1	Parfal									
01.2.01/1	Parfal									
01.3.01/1	Parfal									
01.4.01/1	Parfal									

Remarks:

01**.1.**001/1 means the first two digits is the Cluster-plot number, second digits is plot number in the cluster plot (1-4), the third two digits (01-99) is tree number and the number after slash sign means planting system (1 = Monoculture, 2 = Agroforestry)

Parfal = Abbreviation for species name of *Paraserianthes falcataria* (Sengon), 3 letter of genus and 3 letters of species name

DgL1, DgL2, DgL3 = Damage Location-1, Damage Location-2, and Damage Location-3

DgT1, DgT2, DgT3 = Damage Type-1, Damage Type-2, and Damage Type-3

Svrt1, Svrt2, Svrt3 = Severity-1, Severity-2, and Severity-3

Assessment on vitality of community forest in monoculture and agroforestry planting system derived from the value of the cluster-plots level damage index (CLI = *Cluster-plot Level Index*); by category vitality of community forest monoculture and agroforestry planting system were classified into three classes, namely: good, moderate, and poor obtained from a threshold value of community forest vitality. The threshold values obtained by the vitality of community forests the highest value and the lowest value of the value of the CLI.

CLI value is obtained based on the value of damage index plot level (PLI = *Plot Level Index*) and the tree-level value of the damage index (TLI = *Tree Level Index*); CLI formula (1), PLI (2) and TLI (3) as follows:

$$CLI = \frac{\Sigma PLI}{\Sigma plot} \quad (1)$$

$$PLI = \frac{\Sigma TLI\ in\ plot}{\Sigma\ tree\ in\ plot} \quad (2)$$

$$TLI = [IK1]+[IK2]+[IK3] \quad (3)$$

Wherein, the damage index (IK) is defined as follows:

$$IK = [xdamage\ location*ydamage\ type*zdamage\ severity] \quad (4)$$

Remarks:

x, y, z, is the magnitude of the weighting values vary depending on the degree of the relative impact of each component to the growth and survival of trees.

Each weighting code of damage location, damage type, and severity [8, 13, 19] is shown in Table 4.

Table 4. Weighting value for each code of damage location, damage type, and the severity

Code of damage location	Weighting values (x)	Code of damage type	Weighting values (y)	Code of severity	Weighting values (z)
0	0	01, 26	1.9	0	1.5
1	2.0	02	1.7	1	1.1
2	2.0	03, 04	1.5	2	1.2
3	1.8	05	2.0	3	1.3
4	1.8	06	1.5	4	1.4
5	1.6	11	2.0	5	1.5
6	1.2	12	1.6	6	1.6
7	1.0	13, 20	1.5	7	1.7
8	1.0	21	1.3	8	1.8
9	1.0	22, 23, 24, 25, 31	1.0	9	1.9

3. Results And Discussion

3.1. Damage location, type, and severity

3.1.1. Damage location

The damage location in monoculture planting system was dominated by damage in foliage (code 9) 68%, lower bole (code 3) 16%, lower and upper bole (code 4) 13% and upper bole (code 5) 3%. The damage location on the agroforestry planting system was dominated by damage in foliage (code 9) 71%, lower bole (code 3) 17%, lower and upper bole (code 4) 10%, upper bole (code 5) and branches (code 7)1%, respectively (Figure 2).

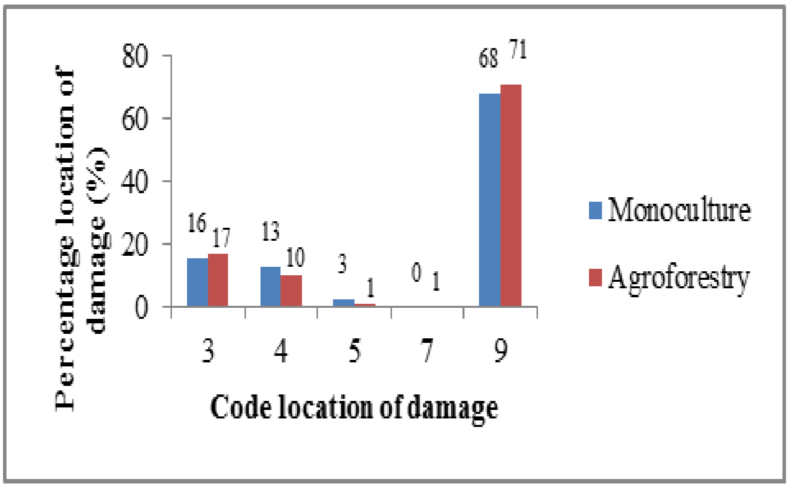

Fig. 2. Tree damage location on community forest in monoculture and agroforestry planting system

Based on Figure 2, the highest damage was located at foliage level (code 9), those were 68% in monoculture and 71% in agroforestry planting systems, as shown in Figure 3. The damage location was mostly on foliage level, because visually at the time of the assessment due to defoliation during dry season where Sengon (*Paraserianthes falcataria*) does not support to the drought. Symptoms of foliage damage was caused by drought and followed by early leaf drop as a symptom in lack of water during dry season. Leave structure of Sengon is double with small secondary foliage [22, 23] that easily falls during lack of water in the foliage levels. These dieback damages will affect to growth retardant to the trees during the dry season.

Fig. 3. Damage location on foliage level (code 9)

3.1.2. Damage type

Tree damage can be caused by many agents (Table 2) resulting different activities in different tree species. The number of tree damage types of Sengon in community forest either in monoculture or in agroforestry planting system is shown Table 5.

Table 5. The number of tree damage types in each cluster-plot in community forest in monoculture and agroforestry planting system

Cluster-plots	Damage codes								
	01	03	04	06	11	20	23	24	26
Monoculture planting system									
1	-	13	-	12	-	-	-	27	-
2	28	-	11	-	-	-	-	48	-
5	-	-	8	-	-	-	-	53	-
6	8	9	-	-	-	-	-	46	-
9	21	10	-	-	-	-	-	44	-
10	13	6	-	-	-	-	-	44	-
13	-	5	-	-	-	5	-	52	-
14	-	8	-	-	-	22	-	9	-
Agroforestry planting system									
3	-	11	-	-	-	-	-	45	5
4	-	-	-	-	-	-	4	75	6
7	13	13	-	-	-	-	-	42	-
8	-	3	-	-	3	-	-	51	-
11	-	11	13	-	-	-	-	51	-
12	16	20		-	-	-	-	13	-
15	-	12	17	-	-	-	-	46	-
16	-	12	8	-	-	-	-	58	-

Table 5 showed that the most prevalent damage types found in cluster-plot of monoculture and agroforestry planting system was foliage damages (code 24), open wounds (code 03), and cancer (code 01), as shown in Figure 4.

Most foliage diseases were caused by insects and fungal infection on the foliage so that the infection can be deadly even to damage the epidermal tissue which in turn causes disturbances in photosynthesis activities. However, damage foliage is not significantly affected to tree health because foliage damage is recoverable during the rainy season.

Open wounds will disturb the activity of the transport of water and nutrients from the soil to the foliage areas. Disruption of the transport of nutrients and water will lead to an imbalance of supply of nutrients and water to the tree parts on it and reduced carbohydrate reserves [24]. According to [25], the stem wound is divided into two parts, namely: (1). wounds limited to the outer timber bark only and (2) wounds the timber barks leading to the sapwood and heartwood injuries. All shapes and sizes can serve as a footprint wound infection, ranging from the wounds inflicted by insect macroscopic lesions due to the activity of cutting up the trunk and branches. Many pathogens that utilize wound infection as an alternative footprint and take advantage through network becomes vulnerable to an open wound on the trunk, followed by the introduction of disease that can lead to stem cancer.

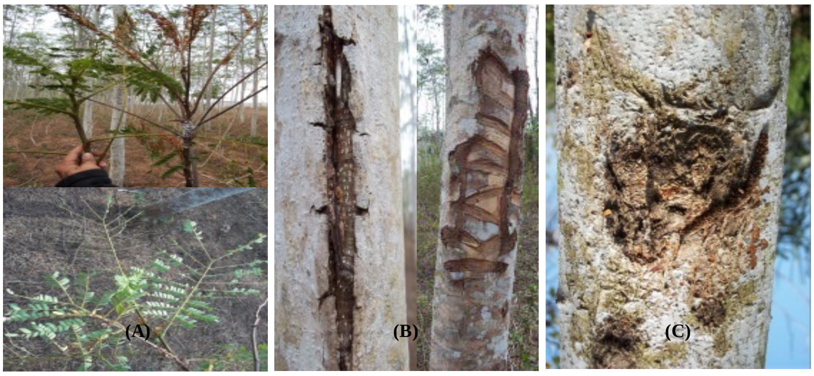

Fig. 4. Damage types: damaged foliage (A), open wounds (B), and cancer (C)

Stem cancer can be affected by seasonal or perennial, so from season to season will be even greater. This damage type can occur in the woody parts, on bark, branches or roots are dried dead parts, demarcated, settle and cracked [26]. Cancer attacks on the cambium so turn off the transport of nutrients and nutrient distribution. According to [27] in the pathogenesis of cancer is more active in areas of high rainfall where many susceptible plants. Besides the susceptible host and virulent pathogen, it is also possible supported by external factors which play an important role. This external factors influence to pathogen indirectly. Stem cancer is mostly caused by a fungus. Mushrooms are one of the causes that give rise to a disease. According to [28] attacks can disrupt the function of the physiology of disease processes including: the establishment of reserve material in the form of seeds, roots and shoots; juvenile on seedling growth and shoot growth; root extension; water transportation; photosynthesis; photosynthesis translocation; and structural integrity; and a disease in plants is essentially the result of the interaction between plants and their causes that can cause symptoms that lead to the respective plant organs can't function properly and then the tree can't grow or develop properly and can't be withheld result as expected [29]. Open wound and stem cancer decreased wood quality in timber harvesting period. Therefore, thinning of damaged trees in Sengon plantation must be done in management decision for increasing the wood quality.

3.1.3. Damage Severity

In terms of damage severity, the number of trees that show a high severity level were found in 83 trees in monoculture planting system and 17 trees were found in the agroforestry planting system with the severity code of 9 (90%). The severity of the highest in monoculture and agroforestry planting system is the severity code 2

(20%) of the damage to the tree, namely: 256 trees in monoculture and 365 trees in agroforestry planting system (Figure 5).

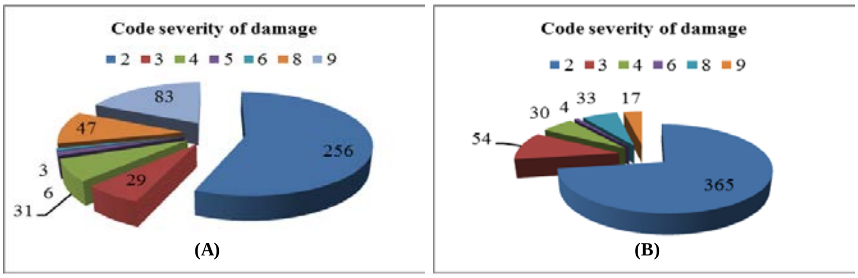

Fig. 5. The damage severity of trees on monoculture (A) and agroforestry (B) planting system

3.2. Damage Level Index

Damage level index is classified in two levels; those are damage level index in plot level (PLI) and in cluster-plot level (CLI). The threshold of damage level index in monoculture and agroforestry planting system is classified into good, moderate and poor (Table 6). The result of vitality status of the community forest is shown in Table 7.

Table 6. Threshold values of vitality in community forests

Class threshold values of vitality in community forests	Vitality categories of community forests
1.51 – 2.81	Good
2.82 – 4.12	Moderate
4.13 – 5.44	Poor

Table 7. Values PLI and CLI each cluster-plot community forest in monoculture and agroforestry planting system

Cluster-Plot	PLI				CLI	Vitality status categories of community forest
	1	2	3	4		
Monoculture planting system						
1	0.87	2.69	1.78	2.11	1.86	Good
2	5.05	3.79	3.78	2.90	3.88	Moderate
5	3.76	0.00	2.74	4.84	2.83	Moderate
6	2.57	2.39	6.89	1.93	3.44	Moderate
9	3.86	1.77	3.22	3.94	3.20	Moderate
10	3.17	0.00	4.37	4.79	3.08	Moderate

Cluster-Plot	PLI				CLI	Vitality status categories of community forest
	1	2	3	4		
13	2.22	1.69	1.44	2.26	1.90	Good
14	3.40	3.83	1.06	0.00	2.07	Good
Agroforestry planting system						
3	2.47	2.19	0.85	2.32	1.96	Good
4	1.83	1.90	1.78	1.78	1.82	Good
7	3.36	1.81	2.79	5.51	3.37	Moderate
8	1.41	1.56	1.47	1.60	1.51	Good
11	2.51	2.12	1.86	1.81	2.08	Good
12	3.65	7.46	5.22	5.45	5.44	Poor *)
15	2.70	2.46	2.57	1.99	2.43	Good
16	2.15	0.00	1.32	2.72	1.55	Good

Table 7 shows monoculture planting system in community forest has value of vitality status between good and moderate, because its CLI value is lower than average value. Low CLI value was affected by damage location and type that mostly damage on the foliage, so that only has a mild impact on the tree health. The value of vitality status in agroforestry planting system was good (6 cluster-plots), moderate (1 cluster-plot) and poor (1 cluster-plot). The cluster-plot number 12 has high CLI value of damage type that was caused by the many open wounds and lower bole. The open wound will disturb the activity transport of water and nutrients from the soil to foliage, which in turn would disrupt optimal tree growth; where lower bole of the tree is very important for producing processed wood.

The management decision for the plantation of Sengon must be emphasized in implementing agroforestry system to minimize the biotic damage and to optimize the production and wood quality. In turn, wood quality will contribute significantly to the local market at Sengon for wood based industry [30].

4. Conclusion

The forest vitality status of Sengon (*Paraserianthes falcataria*) in agroforestry is better than in monoculture planting system. Therefore, agroforestry system is recommended for planting Sengon in the future for minimizing the damage due to biotic and abiotic factors. Open wound and damage buds, foliage and dieback (foliage) were the most important damage in Sengon plantation either monoculture or agroforestry planting systems. Those damages affected to vitality value of plantation which in turn will affect to wood quality and wood quantity. The fact, Sengon woods are important material for wood based industry in Lampung Province, in Sumatera, and other islands in Indonesia.

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