Evaluation of roadside greenbelt trees damage caused by strangler plants in Bogor

Dibyanti Danniswari[1], Nizar Nasrullah[2]

[1]Graduate Student of Department of Landscape Architecture, Faculty of Agriculture, Bogor Agricultural University (IPB), Indonesia;
[2]Department of Landscape Architecture, Faculty of Agriculture, Bogor Agricultural University (IPB), Indonesia

dibyanti@gmail.com

Abstract. Certain plants are called stranglers (hemiepiphyte) because they grow on host trees and slowly choking the host, which often results in the host's death. The existence of strangler plants on roadside greenbelt trees is quite common in Bogor, but they may cause tree's failure and threaten users' safety. To prevent such hazard, evaluation of roadside greenbelt trees damage caused by strangler plants is important. This study was directed to analyse the vegetation of strangler plants in Bogor, to assess the damage caused by stranglers, and to compose strangled trees maintenance recommendations. This study was conducted in March to May 2014 by doing survey at five major roads in Bogor, which were Jalan Ahmad Yani, Jalan Sudirman, Jalan Pemuda, Jalan Semeru, and Jalan Juanda. The results showed that strangler species found in Bogor are *Ficus benjamina*, *Ficus glauca*, *Ficus elastica*, and *Schefflera actinophylla*. The most common species in Bogor is *F. benjamina*. Host trees that tend to be preferred by strangler plants are trees with large trunk, many branches, and medium to high height. The maintenance for every strangled tree is different according to the damage level, mild to severe damage could be treated by strangler root cutting to tree logging, respectively.

Keywords: tree maintenance, roadside greenbelt, strangler plant, hemiepiphyte

1. Introduction

Roadside greenbelt is an area of a road that is designated to be planted with trees, shrubs, or groundcovers. It is an effective type of green space to be used in cities because it does not require large space, but still manage to function as a tool for air and noise pollution mitigation [1]. There are many old and large roadside greenbelt trees in Bogor and it is quite common to find those trees strangled by strangler plants, which are hemiepiphytes. Hemiepiphytes are plants that start their life as epiphytes – plants that grow entirely on other plants – but later live as free-standing individuals by rooting in the ground. They begin their lives as a seed deposited high in a tree by a bird or monkey. They germinate on branches or stems of trees, then grow and develop leaves and roots using nutrient and water resources that accumulate within the crevices of the stem bark [2]. Their roots eventually reach the soil and develop similar root system as their host trees. Usually it takes four or five years until the roots reach the ground, depending on the size of the host tree [3]. Stranglers pass from epiphytic stage in the process and enter a self-supporting stage that function as a normal tree.

Hemiepiphytes are called stranglers because of their roots grow around the host tree and entwine it. As the root diameter increases, they compress the host stem underneath. This process continues until xylem in the host stem can no longer transport nutrient and water upward and therefore dies [2]. Host's

nutrient transport is interrupted because of the strangler, but in most cases, the host is eventually killed by the strangler's dense shade [4]. Even though most stranglers end up killing their hosts, they are not parasites because they do not derive nutrients from the host tree.

The existence of strangler plants on roadside greenbelt trees becomes a problem since their roots keep growing larger, but they only have limited space which later become insufficient for their roots. Strangler plant roots are unable to fully break through asphalt so they cannot grow a deep, strong root system. This issue may cause hazards to the surrounding users or properties, moreover when the host tree is dead. Dead host tree will start decaying and forms a humus for the strangler, leaving a hollow trunk [5]. Dead host tree is more likely to fail since the decaying stem and roots will make the wood structurally weak. When the host tree fail, the strangler roots that grows around the stem is not strong enough to hold the weight of the stem. Therefore, both the host tree and strangler result in failure.

Tree failure tends to happen after extreme weather, such as heavy rain, strong wind, and severe storms. Bogor city has high average precipitation, so climate condition is also a possible threat for users' safety. In 2008, a large, old rubber fig tree (*Ficus elastica*) failed and caused hazards to a school property and a vehicle nearby [6]. Fortunately, there was no victim in the accident. Similar case also happened in 2013 even though the damage was relatively smaller. Similar accident in the future should be prevented, therefore this study was conducted. Evaluation of roadside greenbelt trees damage, specifically caused by strangler plants, is needed before we could suggest the right actions for damaged trees maintenance. There are some major roads in Bogor which its greenbelt trees were seemed to be damaged by strangler plants. Those major roads are Jalan Sudirman, Jalan Juanda, Jalan Ahmad Yani, Jalan Pemuda, and Jalan Semeru. The fact that the traffic intensity at those roads is high makes them in dire need of attention. In order to do the evaluation, this study was directed to analyze the vegetation of strangler plants in Bogor, to assess the damage caused by stranglers, and to compose strangled trees maintenance recommendations.

2. Material and Methods

2.1. Study area and sampling technique

This study was conducted at five major roads in Bogor city, West Java, Indonesia, namely Jalan Ahmad Yani, Jalan Juanda, Jalan Pemuda, Jalan Semeru, and Jalan Sudirman. All of these roads are located in Central Bogor district. These roads have similar macroclimatic condition with average monthly temperature was 32.1° C, the minimum was 22.4° C and the maximum was 33.7° C. Average monthly humidity was 92%. Average monthly rainfall was 304-535.3 mm with highest rainfall occurred in November and February [7]. The data was collected in March to May 2014.

To record the presence or absence of strangler plants in the study area, line-intercept method was used, which–instead of quadrats–was based on a single line of only one dimension, namely length [8]. Sampling of strangler plants was done using a number of 100 m long linear plots located at each roadside greenbelt. Each road has different length as well as the greenbelt. The road length of Jalan Ahmad Yani, Jalan Juanda, Jalan Pemuda, Jalan Semeru, and Jalan Sudirman are ±2.2 km, ±1.7 km, ±1.9 km, ±1.4 km, and ±1.4 km, respectively. Ten linear plots were made at each roadside greenbelt, except at Jalan Juanda. There were only five plots made at Jalan Juanda due to insufficient length of greenbelt. In total, samples were taken from 45 linear plots.

2.2. Strangler plant assessment

The species of each strangler plant found in each plot were identified along with the host tree species. There were four aspects measured in this study: dbh (diameter at breast high), height, canopy diameter, and strangler's coverage over the host tree. Measurement of height and canopy diameter were done separately for the host tree and strangler plant. Tree height was measured using hagameter. For strangler plants, the height was measured from the bottom point of the longest root (nearest to the ground) to the top of its canopy. The number of strangler roots was estimated by counting visible roots. To estimate the coverage of the strangler roots and canopy over the host tree, at least six photos were taken from

different angles; three photos for estimating strangler root density and the other three for strangler canopy density. The coverage was later calculated with digital version of photo grid analysis [9].

2.3. Data analyses

Frequency, dominance, density, and important value index (IVI) of strangler species were calculated following Mueller-Dombois and Ellenberg's method [10]. The IVI were calculated by summing the relative frequency, relative dominance, and relative density for strangler plants. The species diversity index was calculated following Shannon-Wiener index [11], $H = -\sum p_i \ln p_i$; where $p_i = N_i/N$ and $H =$ Shannon-Wiener index of general diversity, $N_i =$ the abundance of the i-th species in the sample.

The measurement data were used for assessing host trees and greenbelts damage. For assessing host tree damage, there were a set of evaluation criteria that consisted of (1) trunk diameter, (2) strangler-host height ratio, (3) density of strangler canopy, (4) density of strangler roots, (5) number of strangler roots, and (6) strangler growth. Those criteria were used to score each strangler plant found in the study area. Measurement data were scored using 5-point scale in each criterion. Table 1-6 presents the score classification for each criterion.

Table 1. Trunk diameter classification.

Score	Qualification	Diameter (cm)
1	Poles	$10 \leq D$
2	Small	$10 < D \leq 30$
3	Medium	$30 < D \leq 60$
4	Large	$60 < D \leq 100$
5	Giant	$D > 100$

Table 2. Strangler-host height ratio.

Score	Qualification	Strangler height (%)
1	Very young	$H \leq 20$
2	Young	$20 < H \leq 40$
3	Medium	$40 < H \leq 60$
4	Nearly adult	$60 < H \leq 80$
5	Adult	$80 < H \leq 100$

Table 3. Density of strangler canopy.

Score	Qualification	Canopy density (%)
1	Very sparse	$C \leq 20$
2	Sparse	$20 < C \leq 40$
3	Moderate	$40 < C \leq 60$
4	Dense	$60 < C \leq 80$
5	Very dense	$80 < C \leq 100$

Table 4. Density of strangler roots.

Score	Qualification	Root density (%)
1	Very sparse	$R \leq 20$
2	Sparse	$20 < R \leq 40$
3	Moderate	$40 < R \leq 60$
4	Dense	$60 < R \leq 80$
5	Very dense	$80 < R \leq 100$

Table 5. Number of strangler roots.

Score	Qualification	Root (pcs)
1	Few	$1 < R \leq 8,25$
2	A few	$8,25 < R \leq 15,5$
3	Some	$15,5 < R \leq 22,75$
4	A lot of	$22,75 < R \leq 30$
5	Most	$R > 30$

Table 6. Strangler growth classification.

Score	Qualification
1	Very few roots, roots have not reached the ground, canopy just starts growing
2	A few roots, some roots have reached the ground, canopy starts growing
3	More roots, many roots have reached the ground, about half of the host's canopy is covered
4	Many roots, most of the roots have reached the ground,
5	So many roots, most part of the stem have been covered by roots, strangler canopy is dominating

After scoring these criteria, the next step was to assess host tree damage. Host tree damage was calculated using the following equation and then the result was classified according to table 7.

$$Tree\ damage\ (\%) = \frac{Sum\ of\ 6\ criteria\ scores}{Sum\ of\ maximum\ 6\ criteria\ scores} \times 100\%$$

Table 7. Classification of tree damage

Stadium	Qualification	Description	Tree damage (%)
1	Mild	Host stem is clearly visible; host canopy is not covered by strangler canopy	$D \leq 20$
2	Low	A small part of host stem is covered by strangler roots; strangler canopy coverage is very small	$20 < D \leq 40$
3	Moderate	About half of host stem is covered by strangler roots; some part of host canopy is covered by strangler canopy	$40 < D \leq 60$
4	High	Almost the whole stem is covered by strangler roots; most of the canopy is covered by strangler canopy	$60 < D \leq 80$
5	Severe	Host stem is fully covered by strangler roots; host canopy is fully covered by strangler canopy	$80 < D \leq 100$

Roadside greenbelt damage was calculated using the following equation and then the result was classified according to table 8. The damage results were then used to estimate the effective maintenance recommendation based on each damage level. The recommendation is expected to be an effective solution for dealing with strangler plants in roadside greenbelts.

$$Greenbelt\ damage\ (\%) = \frac{Sum\ of\ damaged\ trees\ scores}{Total\ trees\ in\ greenbelt\ x\ 5} \times 100\%$$

Table 8. Classification of greenbelt damage

Stadium	Qualification	Greenbelt damage (%)
1	Mild	$D \leq 20$
2	Low	$20 < D \leq 40$
3	Moderate	$40 < D \leq 60$
4	High	$60 < D \leq 80$
5	Severe	$80 < D \leq 100$

3. Results

3.1. Vegetation analysis

A total of 4 strangler species were recorded at the study area, namely weeping fig (*Ficus benjamina*), rubber fig (*Ficus elastica*), bunut (*Ficus glauca*), and umbrella tree (*Schefflera actinophylla*). Among those species, the most frequent one was *Ficus benjamina* with relative frequency 63.6%, and then followed by *F. elastica, F. glauca,* and *S. actinophylla* (table 9). Compared to the other species, *F. benjamina*'s frequency seemed to be significantly different which clearly indicated that it was the most common species found in the study area. From a total of 45 plots, it was found in 28 plots. *F. benjamina* also had the highest density in all study locations with relative density 60.9%, followed by *F. glauca, S. actinophylla,* and *F. elastica* (table 9). There is no certain explanation behind this phenomenon, but it was suspected because *F. benjamina* seeds are easier to be dispersed and/or germinated compared to the

2nd International Symposium for Sustainable Landscape Development

IOP Publishing

IOP Conf. Series: Earth and Environmental Science **91** (2017) 012012

doi:10.1088/1755-1315/91/1/012012

other species and it also has a high degree of flexibility that enables them to adapt with a wide range of habitats. Its rather showy fruit might attract wildlife better than the other species. To germinate, the seeds depend on a bacterium that helps crack its seed coat. Wildlife that eats fig fruits cannot digest the hard seeds, but the outer coat of the seed is dissolved in their stomach during digestion, so the 'uncovered' seeds are later being defecated [3]. If *F. benjamina*'s seed coat is somewhat softer than other species, this might be another possible reason why *F. benjamina* dispersed widely.

Table 9. Strangler plant vegetation analysis results for each species. (F: Frequency, RF: Relative Frequency, De: Density (individual/hectare), RDe: Relative Density, D: Dominance, RD: Relative Dominance, IVI: Important Value Index)

Species	Number of trees	Number of plots	Canopy area (m^2)	F	RF (%)	De (i/ ha)	RDe (%)	D	RD (%)	IVI
F. benjamina	39	28	2648.9	0.6	63.6	7.1	60.9	4.8	61.3	185.9
F. elastica	7	6	1214.7	0.1	13.6	1.3	10.9	2.2	28.1	52.7
F. glauca	9	5	390.8	0.1	11.4	1.6	14.1	0.7	9.0	34.5
S. actinophylla	9	5	64.9	0.1	11.4	1.6	14.1	0.1	1.5	26.9
Total	64	45	4352.4	1.0	100.0	11.7	100.0	7.9	100.0	300.0

Table 10. Strangler plant vegetation analysis results in each greenbelt. FB: *Ficus benjamina,* FE: *Ficus elastica,* FG: *Ficus glauca,* SA: *Schefflera actinophylla.* Total in total plot refers to the number of sampling plots in each greenbelt.

Greenbelt location	Species	Number of trees	Number of plots	Canopy Cover (m^2)	F	RF (%)	De (i/ ha)	RDe (%)	D	RD (%)	IVI
Jalan Ahmad Yani	FB	7	6	507.3	0.6	66.7	5.7	70.0	4.2	90.9	227.6
	FE	3	3	50.6	0.3	33.3	2.5	30.0	0.4	9.1	72.4
Total		10	10	557.9	0.9	100.0	8.2	100.0	4.6	100.0	300.0
Jalan Juanda	FB	3	2	201.8	0.4	50.0	4.9	33.3	3.3	14.7	98.0
	FE	2	1	1138.8	0.2	25.0	3.3	22.2	18.7	82.7	129.9
	SA	4	1	36.4	0.2	25.0	6.6	44.4	0.6	2.6	72.1
Total		9	5	1377.0	0.8	100.0	14.8	100.0	22.6	100.0	300.0
Jalan Pemuda	FB	16	9	412.9	0.9	64.3	13.1	64.0	3.4	88.5	216.8
	FE	1	1	10.3	0.1	7.1	0.8	4.0	0.1	2.2	13.3
	FG	4	1	22.1	0.1	7.1	3.3	16.0	0.2	4.7	27.9
	SA	4	3	21.4	0.3	21.4	3.3	16.0	0.2	4.6	42.0
Total		25	10	466.7	1.4	100.0	20.5	100.0	3.8	100.0	300.0
Jalan Semeru	FB	7	7	870.3	0.7	63.6	5.7	58.3	7.1	70.2	192.2
	FG	5	4	368.7	0.4	36.4	4.1	41.7	3.0	29.8	107.8
Total		12	10	1239.0	1.1	100.0	9.8	100.0	10.2	100.0	300.0
Jalan Sudirman	FB	6	4	656.6	0.4	66.7	4.9	75.0	5.4	96.7	238.4
	FE	1	1	15.1	0.1	16.7	0.8	12.5	0.1	2.2	31.4
	SA	1	1	7.1	0.1	16.7	0.8	12.5	0.1	1.1	30.2
Total		8	10	678.8	0.6	100.0	6.6	100.0	5.6	100.0	300.0

The fact that *F. benjamina* had the highest frequency and density in the study area made it had the highest dominance as well. Dominance is related with strangler canopy coverage. Canopy size could be

determined by genetic factor and adaptability factor. *F. benjamina* has spreading canopy. When it grows older, it tends to use the nutrient for spreading its canopy rather than growing in height. Then the canopy will spread like an umbrella with hanging branch [12]. That factor supports *F. benjamina* to be the most dominating species in the study area. *F. glauca* and *S. actinophylla* had the smallest relative frequency. This low number means their seeds dispersal is limited. Their relative density and dominance also showed low numbers. This might be caused by their unattractive fruits [13] and their rather low adaptability. Similar case might have happened to *F. elastica* as well, but it showed higher relative dominance because there was a large *F. benjamina* tree at Jalan Juanda (table 10).

Table 10 presents strangler plants frequency, density, and dominance at each road. Among the five roadside greenbelts, greenbelt at Jalan Pemuda had the highest total frequency and density. Strangler plants were found in 9 out of 10 plots. This might be caused by the similarities between each plot. Trees continuity in each plot was similar, there was no plot with very distinctive trait, all trees were lined up consistently. Jalan Sudirman had the lowest total frequency (table 10). In contrast to Jalan Pemuda, plots in Jalan Sudirman had high variability, some plots had a lot of trees and the others only had a few. Plots with only few trees lessened the possibility of suitable host tree availability. It is possible for one host tree to be strangled by more than one stranglers. *F. benjamina* nearly had the highest relative density at every greenbelt, except at Jalan Juanda. The highest relative density at Jalan Juanda belonged to *S. actinophylla*. This might indicate that microclimate condition in Jalan Juanda was advantageous for it.

According to the results, strangler species with highest to lowest IVI are the following: *F. benjamina, F. elastica, F. glauca,* and *S. actinophylla*. Highest IVI value belonged to *F. benjamina* with 185.9 (table 9). IVI describes the most dominant and important species in its ecosystem [14]. In terms of roadside greenbelt maintenance, it means that closer attention should be paid to *F. benjamina* since it has the biggest potential to cause damage to greenbelt trees. *S. actinophylla* ranked the lowest IVI, it means the damage caused by it was the lightest.

3.2. Strangler plants diversity
Based on the results, strangler plants had low diversity. Diversity index (H) for Jalan Ahmad Yani, Jalan Juanda, Jalan Pemuda, Jalan Semeru, and Jalan Sudirman was 0.6, 1.1, 1.0, 0.7, and 0.7, respectively. The average was 0.8. According to Shannon and Wiener [11], vegetation with $H \geq 3$ is considered to have high diversity, $1 \leq H < 3$ is considered moderate, and $H < 1$ is considered low. Three of the greenbelts had low diversity, while the other two had moderate diversity. Relatively low diversity may be caused by two possible factors; namely low species variability and/or dominant density by a certain species. Although H value may increase with increasing number of species, it will not work if there is any very dominant species in the study area, because diversity incorporates species richness, commonness, and rarity [15].

3.3. Relationship between strangler plant and host tree
Based on the survey, there were four host tree species, which were *Canarium commune, Samanea saman, Roystonea regia,* and *Thuja orientalis* (table 11). It was found that 59 of 64 host trees (92.2%) were *C. commune*. It was indeed the most common tree species found in the study area. Previous study by Athreya [16] suggested that dominant host tree species is significantly correlated with strangler plants preference of host tree. Another suggestion is that *C. commune* has many branches which is liked by birds. With birds coming and perching on the branch, the possibility they will drop strangler seeds increases. Male and Roberts [17] suggested that strangler distribution is limited by the availability of, and dispersal to suitable host tree. Mostly, stranglers prefer hosts with rough bark. Host's rough bark let strangler seeds be deposited on it and water and nutrient in the crevices will be advantages for them.

Only few host trees belong to species other than *C. commune*. There were some possible factors that explain this situation, which were (1) the host species was not a dominant species, (2) the bark was rather soft, (3) host tree does not have many branches, or (4) it is still a small tree. Previous studies suggested that strangler plants will not likely live on another strangler. Patel [18] suggested that there hasn't been any evidence about strangler that lives on another strangler. It was also confirmed by Titus

[19] saying there is little possibility that a strangler will live on another strangler since their seeds have low survival rate towards pathogen and seed predators, meanwhile those are commonly found on adult strangler trees. It is not likely for a strangler to be a host for another strangler.

Table 11. Host tree and its strangler plant species.

No	Host / Strangler	*F. benjamina*	*F. elastica*	*F. glauca*	*S. actinophylla*	Total	Percentage (%)
1	*Canarium commune*	37	6	7	9	59	92.2
2	*Samanea saman*	1	-	-	-	1	1.6
3	*Roystonea regia*	1	1	-	-	2	3.1
4	*Thuja orientalis*	-	-	2	-	2	3.1
	Total	39	7	9	9	64	100.0

Stranglers' preference of host tree might be affected by the tree's dbh (table 12). Based on survey results, 33 out of 58 strangled trees (56.9%) have large dbh that is more than 100 cm. This showed that stranglers had the tendency to live on large trees. A previous study also showed a similar result, in which stranglers usually found on host trees with large dbh (>80cm) [18]. Another similar trend also found in other studies [16,17]. Larger tree trunk often means older tree. It is suspected the age of the host tree plays an important role in this case. Old trees usually have more crevices that could be where strangler seeds start germinating and also may be better at providing water and nutrients for stranglers.

Table 12. Strangler host preference based on tree trunk diameter.

Strangler	Trunk diameter (cm)					Total
	$d \leq 10$	$10 < d \leq 30$	$30 < d \leq 60$	$60 < d \leq 100$	$d > 100$	
Absent	41	114	206	75	27	463
Present	2	1	8	14	33	58
Total	43	115	214	89	60	521

Another factor that might as well affected stranglers' preference is host tree height (table 13). According to the result, most stranglers tended to live on host tree with height Class 4, which is between 15 to 28 m. It can be seen that 49 out of 58 strangled trees were in this class. This finding could be explained as that is the dominant height of trees in the study area. If it is observed closely, 4 out of 16 trees in Class 5 ($t \geq 28$), equals to 25%, were strangled. Meanwhile, only 49 out of 294 trees in Class 4 that were strangled, which made the percentage equals to 16.67%. With that finding, it is possible if there were more trees in Class 5 in the study area, most of trees in Class 5 might be strangled.

Table 13. Strangler host preference based on tree height.

Strangler	Tree height (m)					Total
	$t < 1$	$1 \leq t < 6$	$6 \leq t < 15$	$15 \leq t < 28$	$t \geq 28$	
Absent	0	41	165	245	12	463
Present	0	3	2	49	4	58
Total	0	44	167	294	16	521

3.4. Roadside greenbelt damage assessment
Damage assessment was done by considering five indicators; trunk diameter, strangler height, strangler canopy density, strangler root density, and number of strangler roots. The assessment results were then classified into 5 classes: mild, low, moderate, high, and severe. Assessments of each tree were used to assess the roadside greenbelt damage.

Table 14. Greenbelt trees damage in the study area.

Greenbelt location	Mild	Low	Moderate	High	Severe	Total	%
Jalan Ahmad Yani	-	6	-	2	2	10	17.2
Jalan Juanda	-	3	2	-	2	7	12.1
Jalan Pemuda	1	13	7	-	1	22	37.9
Jalan Semeru	-	3	1	3	5	12	20.7
Jalan Sudirman	-	3	1	1	2	7	12.1
Total	1	28	11	6	12	58	100.0
Percentage (%)	1.7	48.3	19.0	10.3	20.7	100.0	

Most of the strangled trees found in the study area were under category low damage (table 14). The fact that there were 12 trees that suffered severe damage makes them should be the top priority for further maintenance. If roadside greenbelts were observed as a whole, rather than individual tree, each greenbelt was still in mild damage. Greenbelt trees with highest to lowest damage were the following Jalan Pemuda, Jalan Juanda, Jalan Semeru, Jalan Ahmad Yani, and Jalan Sudirman with damage percentage 5.0%, 7.3%, 11.0%, 6.8%, and 4.3%, respectively. Regardless of the greenbelt damage level as a whole, the attention must be paid to trees individually.

3.5. Maintenance recommendation

Greenbelt trees maintenance should be started with taking care of the stranglers. Stranglers may be treated physically, chemically, and biologically. Since there is not much known about chemical and biological treatment for stranglers, physical treatment seemed to be the most practical way. Physical treatment for each damage level should be differentiated. Trees with mild damage (Stadium 1) could be treated with cutting its strangler roots. Strangler roots should be prevented from reaching the ground since their growth rate will speed up once they get into the ground. Treatment for low damage tree (Stadium 2) should be separating strangler roots that are already attached to stem and cutting all its hanging roots. Any strangler canopy should be cut too. Similar treatment could also be used for tree with moderate damage (Stadium 3), but it needed to be done more carefully since stranglers in Stadium 3 usually have thickened roots and denser canopy. Heavy pruning and cutting should be done on strangler plant in trees with high damage (Stadium 4). Host trees at this stage usually still have strong stem, therefore heavy pruning will still able to save the host tree. Heavy pruning could be done by cutting lateral branches so the stranglers only have one straight stem. While treatment for Stadium 1 to 4 suggests to remove the stranglers, then save the host, treatment for severe damage (Stadium 5) should be done with either logging the tree or leave it be instead, because the host tree probably has died at this stadium. The tree should be logged when it seems to be leaning, but may still be preserved if it has enough space to grow its roots. If the branches are too wide, it will be good to prune them as well. There are several reasons why it should be preserved, strangler tree has aesthetic, architectural, and also ecological value. Strangler could be an element of users' mental map or road identity since it has a unique and remarkable visual. It can also be a nice shade tree and ornamental tree. Ecologically, strangler plants provide food and habitat for wildlife. These physical treatments may not be able to remove the strangler completely, therefore it is needed to do the treatment periodically. In order to maintain every tree in roadside greenbelts, it would be helpful if there were a regular tree 'check-up' so stranglers' growth could be controlled. The survey will might be easier if the tree is numbered.

4. Conclusion

Based on the results, there were four species found in the study area, which were *F. benjamina, F. elastica, S. actinophylla,* and *F. glauca.* Strangler population in the study area was 64 plants and some of them were living on the same host. The most frequent species found was *F. benjamina.* It had the

highest Important Value Index compared to the other species. Strangler diversity in Bogor city was considered low. The most preferred host tree species was *C. commune*. Strangler plants tended to live on host tree with large trunk diameter (>100 cm) and high height ($15 \leq t < 28$). Every greenbelt trees in the study area suffered damage from stranglers. Among 5 greenbelts, Jalan Pemuda had the highest damage and Jalan Sudirman had the lowest damage, but the greenbelt that has severely damaged trees the most is Jalan Semeru. Attention should be paid to each tree individually, specifically trees that suffered severe damage.

Damaged trees should receive different treatment according to their damage level, which were classified to 5 stadiums; mild, low, moderate, high, and severe, with mild is Stadium 1 to severe is Stadium 5. Treatment for damage level 1 to 4 should be focusing on saving the host by pruning and cutting strangler canopy and roots, respectively. If it is not possible to remove the strangler completely, trees that suffered Stadium 4 damage should be heavily pruned so they don't have lateral branches anymore. Treatment for damage level 5 should be done with either logging the tree or leave it be instead. The tree should be logged when it seems to be leaning, but may still be preserved if it has enough space to grow its roots. Trees maintenance should be accompanied with regular tree 'check-up'.

References

[1]   Islam MN, Rahman KS, Bahar MM, Habib, MA, Ando K and Hattori N 2012 Pollution attenuation by roadside greenbelt in and around urban areas *Urban For. Urban Gree.* **11** 460-4 (http://dx.doi.org/10.1016/j.ufug.2012.06.004)

[2]   Medina E 2007 *Functional Plant Ecology 2nd*, ed Pugnaire F and Valadares F (Boca Raton: Taylor & Francis Group, LLC) p 333

[3]   Hood MA 2004 *The Strangler Fig and Other Tales* (Walnut Creek: Altamira Press) p 61

[4]   Lodge TE 2010 *The Everglades Handbook: Understanding the Ecosystem 3rd* (Boca Raton: Taylor & Francis Group,LLC) p 72

[5]   Mattheck C 1998 *Design in Nature: Learning from Trees* (New York: Springer) p 112

[6]   Sulistyantara B 2014 Upaya menurunkan resiko pohon tumbang *Risalah Kebijakan Pertanian dan Lingkungan* **1** 7-11

[7]   BPS Kota Bogor 2013 *Bogor Municipality Figures* (Bogor: BPS Kota Bogor) pxxv

[8]   Mueller-Dombois D and Ellenberg H 1974 *Aims & Methods of Vegetation Ecology* (New York: Wiley& Sons) p 100

[9]   Hall FC 2002 *Photo Point Monitoring Handbook: Part B – Concepts and Analysis* (Pacific Northwest: USDA) pp 59-80

[10]   Mueller-Dombois D and Ellenberg H 1974 *Aims & Methods of Vegetation Ecology* (New York: Wiley& Sons) pp 107-119

[11]   Shannon CE, Wiener W 1963 *The Mathematical Theory of Communication* (Illinois: Urbana)

[12]   Starr F, Starr K, Loope L 2003 *Ficus benjamina* United States Geological Survey, Biological Resources Division, Haleakala Field Station, Maui, Hawai'i

[13]   Gilman EF dan Watson DG 1994 *Schefflera actinophylla: Schefflera* Institute of Food and Agricultural Service, University of Florida

[14]   Fachrul MF 2007 *Metode Sampling Bioekologi* (Jakarta: Bumi Aksara)

[15]   Begon M, Townsend CR and Harper JL 2006 *Ecology: From Indviduals to Ecosystem* (Oxford: Blackwell Publising) p 471

[16]   Athreya VR 1999 Light or presence of host trees: which is more important for strangler fig? *Journal of Tropical Ecology* **15** 589-602

[17]   Male TD and Roberts GE 2009 Host associations of the strangler fig *Ficus watkinsiana* in a subtropical Queensland rain forest *Austral Ecology* **30** 229-36

[18]   Patel A 1996 Strangler fig-host associations in roadside and deciduous forest sites, South India *Journal of Biogeography* **23** 409-14

[19]   Titus JH 2000 *Monteverde: Ecology and Conservation of a Tropical Cloud Forest*, ed Nadkarni NM and Wheelwright NT (New York: Oxford University Press, Inc.) p 71