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# Original Research Article DOI: 10.26479/2019.0502.59 SEEDLING RECRUITMENT OF INDIGENOUS TREE SPECIES WITHIN A *SWIETENIA MACROPHYLLA* KING PLANTATION, MT. MAKILING FOREST RESERVE, PHILIPPINES

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ABSTRACT: Mt. Makiling Forest Reserve is an ASEAN Heritage Park managed by the Makiling Center for Mountain Ecosystem, University of the Philippines Los Baños. In 1940, Permanent Forest Laboratory Areas were developed to establish plantations of S. macrophylla. The species was identified as forest invasive based on a country report (FAO, 2015), thus the planting of the species possess potential threat especially on areas of high nature conservation significance. This study explored on the performance of S. macrophylla and the recruitment of indigenous species inside plantation. Sample plots were randomly established to assess diversity of standing trees and seedlings. Results showed that despite planted as a pure Mahogany stand, several indigenous tree species were already present inside plantation. Presently, the plantation had a composite Shannon's Diversity Index (H') of 2.549 for trees >5cm (Moderately High), whilst seedling diversity had an overall H' value of 1.930 (Very Low). Seedling recruitment of indigenous species was progressing and population of new species coming in was apparent. A total of 44 species belonging to 20 families and 29 genera was recorded in the area. Results suggest that despite identified as bio-invasive where the threat of biodiversity loss to species invasion is high, S. macrophylla was not successful in outcompeting indigenous species on adjacent natural forest. For 75 years after its establishment, the plantation remained and had not expanded towards neighboring natural community.

KEYWORDS: Bio-invasive, Seedling recruitment, Megadiversity, Conservation areas.

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#### **1. INTRODUCTION**

Tropical countries harbor more life forms than any other countries on earth. According to the United Nations Development Programme [1], the Philippines was considered one of the 17 megadiverse countries of the world [2,3,4] hosting about 70-80% of the world's biodiversity. Recently however, the country is facing biodiversity threat due to several human induced factors like deforestation, mineral mining, slash and burn activities among others. Philippine forests were used as a renewable resource. However, with pressure due to increasing population, more agricultural lands and urban areas were required to provide for the basic needs for food and shelter [5]. A huge portion of the country's productive forest areas have been rashly converted into other land uses resulting to a very disturbing decline rate. To address forest loss, several species of trees and agricultural plants were introduced in the Philippines from nearby Tropical and Neotropical countries. Species include Morus alba, Leucaena leucocephala, Acacia mangium, Acacia auriculiformis, Magiifera indica, Eucalyptus globulus, Hevea brasilliensis, Triplaris cumingiana, Tectona grandis, Gmelina arborea, Swietenia macrophylla and many others [6,7]. Big-leafed mahogany (S. macrophylla) is a tropical tree species native to Central and South America. It was first planted in Manila in 1907, then at the Forestry School at Mt. Makiling in 1913 [8]. From then on, S. macrophylla and other exotic tree species like Gmelina arborea and Eucalyptus spp. have been used in government rehabilitation projects all throughout the country. The largest plantations of S. macrophylla have been reported in South and Southeast Asia and the Pacific region wherein significant proportion of the total area, most remarkably in Indonesia and the Philippines, was intended for protection of slopes and water catchments and may not be productive [9]. S. macrophylla was reported as a bio-invasive tree species in the Philippines [8]. The tree produces a hefty number of seeds per fruiting season that developed into drought resistant insect deterrent seedlings. During dry months, the species sheds its leaves forming a thick litter mat. This thick litter mat could be a primary reason why few seedlings are recruited under the plantation. As few seedlings are recruited in the community, plantations of S. macrophylla have the tendency to outcompete adjacent native forest communities especially following disturbance. Though numerous S. macrophylla plantations were already established in Philippine forests years ago, no studies have been done showing the species actual domination by replacing an entire natural forest ecosystem over time. Because of its potential threat, the planting of exotic species was recently highly discouraged especially in areas of high nature conservation significance. Does S. macrophylla pose significant biodiversity threat in Mt. Makiling landscape? As an aspiration to answer this question, this study assessed seedling recruitment of native and indigenous tree species within a S. macrophylla plantation forest to determine performance of seedlings in the Permanent Field Laboratory Area 3 (PFLA3), Mt. Makiling Forest Reserve in UPLB, Los Baños, Laguna.

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# 2. MATERIALS AND METHODS 2.1 Description of the Study Area

The study was conducted within a secondary forest at the northeast slope of Mt. Makiling Forest Reserve. The site was one of the six Permanent Field Laboratory Area (PFLA) established by the College of Forestry and Natural Resources (CFNR) of the University of the Philippines Los Baños (UPLB). PFLA3 was primarily planted with *S. macrophylla* species since 1940 as a demonstration forest with an area of 0.7 hectare, elevation of 199 m above sea level (masl), moderately rolling terrain with a clay loam type of soil [10], and located east of Barangay Galugod Baboy. Mt. Makiling Forest Reserve (MMFR) is an ASEAN Heritage Park spanning a total area of 4,244 hectares straddling parts of Los Baños, Bay and Calamba City in the province of Laguna and Sto. Tomas in the province of Batangas. It is managed by the Makiling Center for Mountain Ecosystem (MCME) under the College of Forestry and Natural Resources, University of the Philippines Los Baños.



# Figure 1: Map of the Mt. Makiling Forest Reserve showing the Northeastern trail with the study site circled in red (In-set). Source: Makiling Center for Mountain Ecosystems 2018 2.2 Focal Species

Big-leafed mahogany (*Swietenia macrophylla* King.) has a wide range of natural distribution and is found in most forest types. A large tree reaching a height of 45 meters with basal girth reaching 300 cm, Mahogany was the most favored reforestation species in most tropical countries. It is native in Central and South America [11], but can grow well in other tropical countries such as Fiji, India, Malaysia, Philippines, Puerto Rico, among others. The species may have been widely planted outside its historical range, however, large areas of former *S. macrophylla* forests have been converted to other uses. The significant depletion of its original populations led to concern for the future of the species and its commercial trade, thus, it is currently included in CITES Appendix II [12,13]. In the Philippines, the species have been popularly used in rehabilitation projects of the © 2019 Life Science Informatics Publication All rights reserved

Peer review under responsibility of Life Science Informatics Publications 2019 March – April RJLBPCS 5(2) Page No.801 Sarmiento RJLBPCS 2019 www.rjlbpcs.com Life Science Informatics Publications government all throughout the country. Some of the large *S. macrophylla* plantations in the country include the Minglanilla Reforestation in Cebu, Paraiso Reforestation Project in Ilocos Norte and the Villa Verde Trail Revegetation Project in Pangasinan.

#### 2.3 Vegetation sampling

The nested plot (quadrat) sampling design was used in vegetation sampling. A total of 15 (10x10m) quadrats with two (2) nested (1x1m) plots were randomly established in the inside and outside of the forest area. Eight (8) quadrats were stationed in the inside whilst seven (7) plots were in the outside portion of the plantation. Veteran *S. macrophylla* trees were located and marked to serve as boundaries of PFLA3. For each 10x10m quadrat, all trees species having dbh >5 cm were recorded. All juvenile seedlings <5 cm dbh and 0.5 m in height were recorded for the nested 1x1m plots.

## 2.4 Data Processing and Analysis

The data gathered was processed using codes and encoded in a spreadsheet. Descriptive analyses such as means and frequency were taken and subsequently transformed to tables. The Palentological Statistics Software (PAST Statistical Software V. 2.14) was used to compute site biodiversity indices.

## **3. RESULTS AND DISCUSSION**

# **3.1 Species Richness in PFLA3**

PFLA3 was established in 1940 to maintain a plantation of *S. macrophylla* for research purposes to better understand the dynamics of tropical forests. Though it was started as a pure mahogany plantation, other forest species have been recruited on the site within the course of time. In this study, a total of 31 tree species with dbh > 5cm were found inside PFLA3. Figure 2 shows the most frequently occurring tree species. Expectably, *S. macrophylla* recorded the highest percentage of individuals (38.30%) in the plantation area. The interesting point is that other indigenous species were also found inside the plantation such as White lauan (*Shorea contorta*), Banaba (*Lagerstroemia speciosa*) and Ipil (*Intsia bijuga*) comprising 13.83%, 4.26%, and 4.26%, respectively. Other species recorded but not listed in the table were encountered once in the field.



# Figure 2: Most frequent tree species >5 cm in PFLA 3. © 2019 Life Science Informatics Publication All rights reserved Peer review under responsibility of Life Science Informatics Publications 2019 March – April RJLBPCS 5(2) Page No.802

Sarmiento RJLBPCS 2019 www.rjlbpcs.com Life Science Informatics Publications The plantation was raised as a pure S. macrophylla stand in early 1940s, recent findings denote that the plantation has been slowly transforming into a mixed-species type as new species of forest trees were gradually recruited inside and outside the plantation boundary. The findings corresponded to the previously conducted study of Florentin and Bounmmithanh [14] on the performance of S. macrophylla in the same site of Mt. Makiling. The juvenile wildlings were assessed using nested 1 x 1m plots within the sampling plots to determine seedling species richness and diversity. The researcher used species curve to estimate number of plots necessary for the sample. It was observed that the number of species encountered peaked at plot 12 with a total of 27 species. Subsequent plots yield no additional species thus 15 plots is good enough to estimate species richness of regenerations in PFLA3. Figure 3 shows the most abundant regenerants inside and outside the study area. Similar to tree species with dbh > 5cm, S. macrophylla seedlings were recorded to be the most abundant seedling in PFLA3 comprising 37.52% for all species recorded (Fig. 4). S. macrophylla seedlings were observed present in all sampling plots inside and outside the plantation due to the presence of recently fruiting S. macrophylla mother trees. Other wildlings recorded include S. contorta (25.31%), Celtis luzonica (10.82%), Parkia javanica (8.73%) and Pterocarpus indicus (5.41%).



Figure 3: Summary of most abundant seedlings in PFLA 3.

*S. macrophylla* produces enormous number of seeds per fruiting season. If all seeds released will germinate and survived, the species will undoubtedly invade natural ecosystems. However, the seedling survival rate of *S. macrophylla* was lower compared with other natural forest species like *Strombosia philippinensis*, *Artocarpus ovata*, and *Diospyrus pilosanthera* which were also present in the area [15,16]. In Brazil, it was reported that only 1-2% of seedlings in the understory survived 8 years after germination [17]. Four months after the first survey visit, the indigenous seedlings recorded just once or twice in the field were still present and had survived. This is an indication that despite large number of seeds released by *S. macrophylla*, only few individuals will survive and

Sarmiento RJLBPCS 2019 www.rjlbpcs.com develop into saplings within a natural forest area.

#### 3.2 Population structure of tree components in PFLA3

S. macrophylla was introduced in Mt. Makiling Forest Reserve in 1913 in connection with the reforestation management program [8]. The tree was observed to have various growth stages ranging from seedlings to saplings with dbh of 3 cm to large trees with a dbh of 206 cm in the study site. Onsite, it dominated the over-story vegetation. Some palm species belonging to Family Araceae (Areca catechu and Arenga pinnata) were also observed as minor components of the over-story, however, these species were not measured for analysis. A total of 94 individual trees belonging to 20 families and 29 genera were found in the study area. The stand can be classified as a young growth with mean diameter at breast height (dbh) of 28.61±6.28 cm which also conformed with the findings a different study [10]. Fifty-seven percent were classified as small trees, 31.9% as mediumsize trees and only 10.6% were large trees. Of all species, S. macrophylla ranked 1<sup>st</sup> with the highest importance value for all trees >5 cm dbh in PFLA3. Most of the recorded S. macrophylla were matured individuals with diameters ranging from 40 - 85 cm. Dipterocarp species such as S. contorta and S. guiso ranked 2<sup>nd</sup> and 3<sup>rd</sup> in importance values, respectively (Table 1). The PFLA3 was adjacent to a second growth mixed forest; hence, an ecotone was developed between the two forests. It was observed that Dipterocarp species have slowly diffused into the pure mahogany stand as dipterocarp seedlings can tolerate low light intensity and benefit from partial shade during establishment and subsequent growth [18,19,20,21]. Mahogany seedlings and other indigenous tree species encountered inside the plantation occurs in small gaps following natural disturbance (Typhoon Xansane in 2006) [22] which created conditions favorable for its growth [11,23,24]. Although canopy opening is necessary for successful regeneration, Mahogany [17] and dipterocarp seeds do not germinate and establish well on exposed mineral soil in full sunlight [25], and when established seedlings are grown in full sunlight, their growth rates (height or stem diameter) are the same or less than that observed under partial shade [18,19].

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Snecies	Relative	Relative	Relative	SIV	
Species	Freq	Den	Dom	51 4	
Swietenia macrophylla	17.021	38.298	44.861	100.180	
Shorea contorta	6.383	13.830	14.754	34.967	
Shorea guiso	4.255	3.191	4.906	12.353	
Lagerstroemia speciose	4.255	4.255	1.714	10.225	
Intsia bijuga	4.255	4.255	1.457	9.967	
Cedrela odorata	2.128	1.064	5.962	9.154	
Canarium aspermum	4.255	2.128	2.113	8.496	

# Table 1: Summary of Relative Frequency, Relative Density, Relative Dominance and SpeciesImportance Value of trees with DBH > 5cm in PFLA 3

Tot	tals	100.000	100.000	100.000	300.000
Ter	rminalia microcarpa	2.128	1.064	0.170	3.361
Ma	ullotus philippinensis	2.128	1.064	0.195	3.386
Vite	ex parviflora	2.128	1.064	0.222	3.413
Viti	icipremna philippinensis	2.128	1.064	0.222	3.413
Fic	cus ulmifolia	2.128	1.064	0.280	3.472
He	ritiera sylvatica	2.128	1.064	0.382	3.573
Syz	zygium calubcob	2.128	1.064	0.419	3.610
Spa	athodea campanulata	2.128	1.064	0.458	3.649
Fic	cus nota	2.128	1.064	0.498	3.690
Dip	plodiscus paniculatus	2.128	1.064	0.541	3.732
Ail	anthus integrifolia	2.128	1.064	0.631	3.822
Ма	icaranga tanarius	2.128	1.064	0.779	3.970
Dy.	soxylum decandrum	2.128	1.064	0.886	4.078
Ce	ltis luzonica	2.128	2.128	0.364	4.620
Gn	ielina arborea	2.128	2.128	0.541	4.796
Alp	ohonsea arborea	2.128	1.064	1.753	4.944
Poi	ngamia pinnata	2.128	1.064	1.753	4.944
Als	tonia scholaris	2.128	2.128	1.264	5.519
Gre	ewia multiflora	2.128	2.128	1.264	5.519
Art	tocarpus ovatus	2.128	1.064	2.618	5.809
Pla	anchonia spectabilis	4.255	2.128	0.974	7.357
Lit	chi chinensis	4.255	2.128	1.403	7.786
Pat	rkia javanica	2.128	1.064	4.739	7.931
Pte	erocarpus indicus	4.255	2.128	1.881	8.264

#### 3.3 Species diversity in PFLA3

Shannon's index of diversity was computed for each plot and the whole site to determine species diversity and provide information about the composition of the community. Results showed that the site has a composite Shannon's diversity index (H') of 2.549, considered to be "Moderately High" based on the relative scale developed by Fernando [26]. The H' values for all plots ranged from 0.000 to 1.834 for trees (>5 cm dbh) and 0.706 to 1.752 for juvenile seedlings. Plots having diversity values equal to 0.000 (plots 1, 2, 4, and 6) meant that the plot is composed solely of a single species (*S. macrophylla*), hence no diversity.

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#### Figure 4: Shannon's diversity indices of the sample quadrats in PFLA3 (Trees >5cm dbh)

The recruited juvenile seedlings (Fig. 5) have an overall index H' value of 1.930, 24% lower than trees having dbh >5 cm. A total of 13 regeneration species were recorded despite absence of mature trees in the site to include *Canarium luzonicum*, *Cavanillesia hylogeiton*, *Diospyros digyna*, *Strombosia philippinensis* and others. These species may have been transported by wind or wildlife or by anthropogenic activities like students doing research. Plots located near the center of the plantation were dominated by *S. macrophylla*, thus the diversity of the nested plots is low.



#### Figure 5: Shannon's diversity indices of nested plots in PFLA3 (Seedlings <5 cm dbh)

The nested plots located in-between zones of mixed forest and the mahogany plantation have a higher seedling diversity compared to those inside the plantation. As winged seeds of *S. macrophylla* are easily dispersed by wind [27,28], the germinated seeds have low survival rates [15] and were outcompeted by other indigenous trees species undershade [29] before fully establishing into sapling

Sarmiento RJLBPCS 2019 www.rjlbpcs.com Life Science Informatics Publications stage . Four (4) months after the first inventory, no newly developed *S. macrophylla* saplings were observed in plots outside plantation boundary.

## 4. CONCLUSION

PFLAs were developed in view of the need for permanent plots that will generate data useful in the understanding of the dynamics of a tropical forest ecosystem [30]. PFLA3 was intended to grow *S. macrophylla* plantation for research purposes and was established in the early 1940s. Despite planted as pure stand, several species have been recruited into the site naturally. In this study, a total of 44 species were recorded for trees and seedlings, an indication that the species richness within the PFLA is increasing through time. Timber producing indigenous species such as *S. contorta*, *S. guiso*, and *P. indicus* were observed to be growing well and gradually increasing in population together with *S. macrophylla* inside plantation area. The area has a composite Shannon's Index (H') value of 2.549, considered moderately high for a forest ecosystem. The Mahogany plantation in PFLA3 has been in existence for the past 75 years. Study shows that Mahogany may have been the most dominant species in the area, the present study was consistent with results from prior studies [28,31] that the planted species had not shown "signs of invasive spread" and that the species have not successfully outcompeted other forest trees. Seedling recruitment of other indigenous species to the inside of the plantation was significantly increasing.

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#### **CONFLICT OF INTEREST**

There are no conflicts of interest.

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