Review of Tree Species in Dry Dipterocarp Forest, Savannakhet Province, Lao PDR

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Abstract

The aim of this research was to estimate the relationship between tree density and elevation of tree species in Dry Dipterocarp Forest. Methods applying for this study used ground verified plot inventory from Phaipalath et.al (2018) to regenerated analysis 6 sites, data analysis applied several techniues of statistics, such as descriptive analyisis and linear regression. The results found that there were 6 species and 3 genuses that are significant dominance in Dry Dipterocarp Forest site in Laos. The largest species is *Shorea sp*, it is highest density contributing in everywhere of elevation levels from 124 to 218 m. Relationship between density and elevation of tree numbers increased based on different sea levels showed significantly at R^2=0.57, *Dipterocarpus obtusifolius* decreased in low elevation significantly at R^2=0.63, *Shorea siamensis* increased significantly at R^2=0.74, in high elevation. The tree species of *Xylia xylocarpa, Cratoxylum formosum and Vatica odorata* were low significantly correlation with the sea elevation at R^2<0.5.

Keywords: *Habitat specificity, tree diversity, dry dipterocarp forest, elevation, relationship.*

1. Introduction

The Ministry of Agriculture and Forestry (2005) reported that the forest land area has been decreasing recently, from approximately 70 % of land area in 1950 to 41.5 % in 2002 and 40.29 % in 2010. The Dry Dipterocarp Forest (DDF) is remaining the largest forest in Lao PDR. This DDF is mainly occurred in the southern part of Laos, especially in the 5 districts of Savannakhet Province (Xonnabouly, Phin, Songkhone, Phalanxay and Thapangthong), where were defined as the Eld's Deer Sanctuary. The Eld's Deer Sanctuary area has totally 140,810 ha (including its extension area). This area is also covering various forest habitats that are mainly lowland and low mountain places in the southern part of Laos. This forest areas have a connecting to the Xetanouan–Phounak National Protection Forest, and at Padong that belongs to Thapangthong and Phin Districts. The Padong forest zone has several habitats and many micro-habitats, including eco-tone between DDF and Mixed Dry Forest (MDF) at the Padong (Phaipalath et al., 2018). Singh et al. (2016) found that a plant community is a collection or association of plant species within a specific location, which forms a relatively uniform patch, distinguishable from neighboring patches of different forest types. Plant community descriptions provide information regarding the status of tree population, regeneration, diversity, habitat and associated species (Malik & Bhatt, 2015). The knowledge of plant community provides a common framework for ecologists, foresters, environmental planners, and others researchers to use in a variety way, including vegetation mapping, ecological restoration, environmental planning, planning and implementation of the conservation strategy of the community (Bhatta & Devkota, 2020;

Rahman et al., 2011). DDF is important point for wildlife feeding in the raining season as the DDF has rich grasses due to the under DDF is most clear.

Agricultural land areas and dams have been largely cleared and seems trending to be increasingly threatening in the future. The World Wildlife Fund (WWF) considers the Central Indochina Dry Forest to be "Globally Outstanding" in its biological distinctiveness, and rates its conservation status as "Vulnerable (Wikramanayake, 2002). Laos has less than 1% of the Open Dipterocarp Forest that is suitable for Eld's deer inhabitation in the national protected areas system (McShea et al., 2005). The MDF is characterized by the tall and diverse canopy structure with a large dominance of deciduous species. The forest stories are not as dense as those of evergreen types and most of the seedlings and saplings are deciduous tree species. MDF has the largest diversity of botanic species and the commonly observed species as Wild Siris Albizzia codorostima, which are included for example, the tree species of *Artocarpus lakoocha*, *Dipterocarpus alatu*s, Pelcinwood Dysolxylum binectariferum, *Lagerstroemia floribunda*, *Pethophorum dasyrhachis*, and Pometia pinnata. Others tree species are also included Pterocarpus macrocarpus, Mai Bark Chochinchine Ribbed leaf tree *Anisoptera chochinchinensis*, Mai Si Harman Resintree Vatica harmandi, Mai Nyomhin Hard woody Gooseberry tree *chukrasia tabularis* and Mai Deng Red woody tree *Xylia xylocarpa*. (Phaipalath et al., 2018). Tree species contribution in DDF

Gardner et al. (2000); (Rundel, 1999) defined that Dry Dipterocarp means "dry dipterocarp forest," "deciduous dipterocarp forest," and "Central Indochina Dry Forest" occurs across lowland areas (<800 m) of Southeast Asia, where there is 1000–1500 mm of rainfall and 5-7 months of drought. Open Dipterocarp forms a low, open forest or woodland, typically with 60% canopy cover, trees at 15 m height in average, and few understory species (Gardner et al., 2000). Dry Dipterocarp exists in four countries in southeast Asia included Laos, Thailand, Vietnam and Cambodia. The largest Dry Dipterocarp Forest is in Cambodia (Wikramanayake, 2002). The Dry Dipterocarp Forest in Laos is the sampling site of the Eld's Deer Sanctuary that has also included the Mixed Deciduous Forest (MDF)/Semi-Evergreen Forest in the site. The DDF occurs as open stands where are generally found in places with laterite, shallow soils characterized by a hard pan and topsoil in sandy grey, with trees being of relatively small size - a maximum stand height of 25 meters. Dry tropical forests are smaller in stature and less complex floristically and structurally about half compared to the wet tropical forests (Murphy & Lugo, 1986). There are also only one or two canopies, with overall small structure and low biomass. In the rainy season, these soils are prone to flooding and eroding, while in the dry season they are susceptible to droughts. Most of the tree species in the dry forest are drought and fire-resistant (Bunyavejchewin, 1983).

Base on Rundel (1999) identified that forest was dominated by deciduous trees, particularly by four species from the family of Dipterocarpaceae – *Dipterocarpus tuberculatus, D. obtusifolius*, *Shorea obtusa,* and *S. siamensis*. There is also a reasonable diversity of other small trees, and the ground layer is dominated by grasses. Fire was common in this habitat, and species are adapted to fire. The majority of the species belong to the Darmar resin (Yang oil) family of Dipterocarpaceae, with the most common species as Mai chik Darmar resin tree Shorea obtusa, Mai hang Siam Darmar resin *S. siamensis*, Mai koung large leave Yang oil *Dipterocarpus tuberculatus,* Mai sat Obtuse leaf Yang oil *D. obtusifolius*, Mai seuak Black Leadwood *Terminalia sp*, Mai deng Redwoodytree *Xylia xylocarpa* var. kerrii. In addition, in some mixed dry forest plots we can also find Mai dou Sandalwood *Pterocarpus macrocarpus*, Mai bark Ribbed leaf tree *Anisoptera costata* Korth, Mai khayom Roxburgh Darmar resin *Shorea roxburghii* G.

Dong etc. All the list trees species mentioned above are significant in Lao wood commercial tree species approved by the Lao government.

The objectives in this research focused on literature review of tree species contribution and habitat in different sea elevations in the dry dipterocarp forest. This study analyzed by comparing the relationship between tree species density and elevation.

2. Materials and Methods

The equipment for this research were mainly camera with good shooting lens capacity, GPS, Guidelines plants, Data Forms, 5m meter tape measure, plastic rope, and camps. This study was divided in three steps according to (Phaipalath et al., 2018). The detailed methods were as below:

Step 1: Sampling plot design by applying the circular sampling plot method with a radius of 17.85 meters (or 0.1 ha) and GPS marking to the plots. Then plot boundary was marked by using plastic string tape from the center plot to around the plot.

Step 2: Tree measuring used tap meter, then measured for tree diameters at breast height (DBH), especially for the trees that are bigger than 10 centimeters.

Step 3: Species identification in local and scientific names by using the field plant guideline.

All the available research articles in Laos and Asian countries of Dry dipterocarp were reviewed and compared and discussed with in this study information. The trees species and forest types, and forest characteristics in the study sites were main key words for comparison. The research was followed by (Phaipalath et al., 2018) to use tree species in top 15 species in each ground sample plots measuring. It is available 6 sites in Sanvanakhet Dry Dipterocarp forest. The information focused on tree density (tree/ha), and different evalutions. Number tree species of (Phaipalath et al., 2018) in top 15 tree species that are avalable in 6 sites were used generated re-analysis of tree density, ranging high to low density in number of tree per ha. Data analysis applied several techniues of statistics, such as descriptive analyisis and linear regression to compare and see the relation between tree species density and different sea elevations in the study site.

3. Results

Table 1 showed that the density of tree species (tree/ha) and standard error in Dry dipterocarp Forest reported from (Phaipalath et al., 2018) were ranged 15 top tree species in each point ground sampling plot. There were 57 tree species finding in 6 sites contribution, the number of dominance species in DDF were available 6 trees species. The highest density was Mai Chik Darmar *Shorea obtuse* (Dipterocarpaceae) with an average of 50 trees/ha. This species contributed from the elevation between 124-218 m. Maisad Obtuse leaf Yang oil *Dipterocarpus obtusifolius* (Dipterocarpaceae) was 22 trees/ha; it contributed from elevation from 124-175 m. Mai hang *Shorea siamensis* (Dipterocarpaceae) was 14 trees/ha; it contributed from elevation from 164-281 m. Mai deng *Xylia xylocarpa* (Fabaceae) was 12 trees/ha; it contributed from elevation from 124-218 m. Mai tiou khao *Cratoxylum formosum* (Guttiferae) was 8 trees/ha; it contributed from elevation from 146-218 m and Mai si *vatica odorata* (Dipterocarpaceae) whit density 8 trees/ha; it contributed from elevation from 161-185m, respectively followed by another 51 tree species ranked logically.

The review finding that Mai chik Darmar resin tree *Shorea obtusa* and Maisad Obtuse leaf Yang oil *Dipterocarpus obtusifolius* (Dipterocarpaceae) were different contributing to different sea revelations. Mai Yang oil *Dipterocarpus obtusifolius* was not found above 180 m of the sea elevation.

Figure 1 showed that *Shorea obtusa* species contributed significantly at R^2=0.5717, which it was highest dominant tree species and found in different levels of sea elevation. The second dominant tree species occurred in the study site was *Dipterocarpus obtusifolius.* This

species contributed significantly at R^2=0.63 correlation to the sea elevation with a high-density points 124-138 m but it decreased density in elevation higher and was not occurred the elevation above 180 m in the study sites. Figure 2 indicated that *Shorea siamensis* tree species was found above points of 164-218 m of sea elevation at statistical significantly R^2=0.74. The figure 3 also found that *Shorea siamensis* species occurred at the sea elevations from 124-218 m at R^2=0.0083 significantly relation to the sea elevation. Figure 4 showed that *Cratoxylum formosum* species contributed at different sea elevations from 168 up to 218 m, which have a significant relation at R^2=0.248. The contribution of *vatica odorata* was found at points 161-185 m of sea elevations with statistical significantly at R^2=0.0065.

4. Discussion

The results analyzed from this study were similar to the previous study of Khamyong et al. (2018), in Northern Thailand. However, in this study the density of tree species was available only 57 tree species which lesser than the resulted studied in Thailand of 85 tree species. For the top 10 species in Northern Thailand that discovered including *Dipterocarpus obtusifolius (262 stems.ha^{-1}), Dipterocarpus tuberculatus (485 stems.ha^{-1}), Shorea obtuse (321 stems.ha^{-1}), Shorea siamensis (266 stems.ha^{-1}), Tristaniopsis burmanica (460 stems.ha^{-1}), Gluta usitata (170 stems.ha^{-1}), Quercus kerrii (162 stems.ha^{-1}), Wendlandia tinctoria (192 stems.ha^{-1}), Quercus brandisiana(57 stems.ha^{-1}), and Aporosa villosa (166 stems.ha^{-1})*. Laos and Thailand DDF species were similarly. Based on Tuan et al. (2021) reported that 54 tree species in DDF in the Central Highlands Region. The dominant species are *Shorea siamensis, Shorea obtusa, Xylia xylocarpa, Terminalia alata, Dillenia sp, Dipterocarpus tuberculatus, Aporosa villosa, Dipterocarpus obtusifolius, Elaeocarpus hygrophilus and Syzygium cumini*. This study was similar tree species and density closly. dominant tree species are *Shorea obtusa Miq. Dipterocarpeae (171 stems.ha^{-1}), Dipterocarpus tuberculatus (100 stems.ha^{-1}), Xylia xylocarpa (25 stems.ha^{-1}), Terminalia alata (20 stems.ha^{-1})* and Mondulkiri Forest Protected (MPF) which has elevation 220 m.a.s.l, This study compared tree species with Pin et al. (2013) was similar tree species as *Shorea obtusa Miq. Dipterocarpeae (512 stems. ha^{-1}), Dipterocarpus tuberculatus (418 stems. ha^{-1}), Terminalia alata (80 stems. ha^{-1}), Terminalia alata(18 stems.ha^{-1}), Xylia xylocarpa (8 stems.ha^{-1}),* but density of tree species in this study was lower. DDF in Southeast Asian was similar tree species, genus but Laos tree density was lowerothers countries ranging from two to four times.

In comparison of Laos sea evaluation to others Asian countries sea elevations are also significantly. This study showed that the DDF elevation of Laos was lower than Thailand's DDF by ranging of three to four times (200, and 900 m respectively). Based on Tuan et al. (2021) studied in Vietnam and the results showed that in average the Vietnam altitude is 500–600 m, which was higher than this study results in Laos of two to three times by comparing. In conclusion, Laos and Cambodia's DDF were lower than Thailand and Vietnam's DDF.

5. Conclusion

There were three main dominant genus occurred in the DDF of Laos, which were included Dipterocarpaceae, Fabaceae and Guttiferae. Total 57 species found in the DDF in Savannakhet, and there were only 6 dominant trees species in the study site. These dominant species that contributed to the study stie included *Shorea obtuse* occuring in every elevation, *Dipterocarpus obtusifolius* finding only at the elevation less than 175 m of sea level, the *Shorea siamensis species* contributed during 164-281 m of sea level, the *Xylia xylocarpa* existed at every plot but number per hectare of this species was low, the *Cratoxylum formosum* contributed 146-218 m of sea level and *Vatica odorata* contributed during 161-218 m of sea level. Species of DDF in Laos was similar to the other DDF in the different regions such as Thailand, Vietnam and Cambodia. Those countries confirmed that the dominant DDF tree

species was *Shorea sp*, therefore it was noted able that due to different elevations and climate conditions may cause different density of tree species and habitats.

6. Conflict of Interest

We certify that there is no conflict of interest with any financial organization regarding to the material discussed in this manuscript.

7. Acknowledgments

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Table 1. List of tree species available in Dry Dipterocarp Forest

No	Trees species	Local Name	Family Name	Density (trees/ha)	SE	Elevation (m)
1	*Shorea obtusa*	Mai chik	Dipterocarpaceae	50	13.98	124-218
2	*Dipterocarpus obtusifolius*	Mai sad	Dipterocarpaceae	22	16.24	124-175
3	*Shorea siamensis*	Mai hang	Dipterocarpaceae	14	6.62	164-281
4	*Xylia xylocarpa*	Mai deng	Fabaceae	12	3.92	124-218
5	*Cratoxylum formosum*	Mai tiou khao	Guttiferae	8	4.59	146-218
6	*vatica odorata*	Mai si	Dipterocarpaceae	8	6.04	161-185
7	*Terminalia mucronata*	Mai peuay nam	Combretaceae	6	3.97	161-218
8	*Irvingia malayana*	Mai ka bok	Irvingiaceae	5	3.17	161-168
9	*Peltophorum dasyrrhachis*	Mai a rang	Fabaceae	5	2.96	146-218
10	*Mitragyna rotundifolia*	Mai thom kok	Rubiaceae	3	2.11	164-185
11	*Aporosa villosa*	Mai Meuad khon	Euphorbiaceae	3	2.79	161-185
12	*Syzygium oblatum*	Mai war khao	Myrtaceae	3	3.00	124-138
13	*Symplocos sumuntia*	Mai Meuadta khouay	Symplocaceae	3	2.40	124-175
14	*Parinari anamense*	Mai Phok	Chrysobalanaceae	3	1.90	124-168
15	*Dillenia ovata*	Mai San	Dilleniaceae	3	2.16	161-185
16	*Lagerstroemia floribunda*	Peuaydokdeng	Lythraceae	3	3.00	176-218
17	*Pterospermum acerifolium*	Mai ham ao	Sterculiaceae	3	2.01	164-281
18	*Aporosa villosa*	Mai meuad khon	Euphorbiaceae	3	2.83	116-185
19	*Syzygium siamense*	Mai wa nam	Myrtaceae	3	2.67	124-138
20	*Dialium cochinchinensis*	Mai Kheng	Fabaceae	2	2.33	161-175
21	*Dipterocarpus intricatus*	Mai Sa beng	Dipterocarpaceae	2	2.33	161-175
22	*Sindora siamensis*	Mai te hor	Fabaceae	2	1.01	124-218
23	*Ellipanthus tomentosus*	Mai tanokkot	Connaraceae	2	2.17	146-168
24	*Semecarpus cochinchinensis*	Mai Hang hon	Anacardiaceae	2	1.48	124-194
25	*Pterocarpus macrocarpus*	Mai dou	Fabaceae	2	1.20	124-218
26	*Diospyros ehretioides*	Mai Heuan khouang	Ebenaceae	2	1.22	124-168
27	*Microcos tomentosa*	Mai makkhom	Tiliaceae	2	1.83	164-194
28	*Memecylon edule*	Mai mak khom	Tiliaceae	2	1.09	124-185
29	*Rothmannia wittii*	Mai mak mor	Rubiaceae	2	1.67	164-194
30	*Lophopetalum wallichii*	Mai Phan si	Celastraceae	2	1.50	161-175
31	*Chaetocarpus castanocarpus*	Mai bok khai	Euphorbiaceae	2	1.50	164-194
32	*Cratoxylum cochinchinense*	Mai tiou deng	Guttiferae	2	1.50	164-194
33	*Anisoptera costata*	Mai bark	Dipterocarpaceae	2	1.50	146-168
34	*Hopea odorata*	Mai Khen Yong	Dipterocarpaceae	1	1.33	161-175
35	*Lagerstroemia calyculata*	Peuay dok khao	Lythraceae	1	1.33	164-194
36	*Terminalia mucronata*	Mai peuay nam	Combretaceae	1	1.33	176-218
37	*Vitex pinnata*	Mai tin nok	Lamiaceae	1	1.17	164-194
38	*Bombax anceps*	Mai ngioukhao	Bombacaceae	1	1.17	146-168
39	*Cleistocalyx nervosum*	Mai wardong	Myrtaceae	1	1.17	146-168
40	*Garcinia merguensis*	Mai som mong	Guttiferae	1	1.17	146-168
41	*Hopea ferrea*	Mai khen hin	Dipterocarpaceae	1	1.17	176-218
42	*Shorea roxburghii*	Mai khen kha yom	Dipterocarpaceae	1	1.00	124-138
43	*Castanopsis sp.*	Mai Ko nam	Fagaceae	1	1.00	164-194
44	*Homalium tomentosum*	Mai khen nang	Flacourtiaceae	1	1.00	164-194
45	*Syzygium cumini*	Mai war kok	Myrtaceae	1	0.83	161-175
46	*Mitragyna hirsuta*	Mai thom phai	Rubiaceae	1	0.83	116-185

No	Trees species	Local Name	Family Name	Density (trees/ha)	SE	Elevation (m)
47	*Dipterocarpus alatus*	Mai yang na	Dipterocarpaceae	1	0.83	176-218
48	*Terminalia alata*	Mai seuak	Combretaceae	1	0.83	176-218
49	*Elaeocarpus sphaericus*	Mai Ka seou	Elaeocarpaceae	1	0.67	124-138
50	*Careya sphearica*	Mai Ka don kok	Lecythidaceae	1	0.67	116-185
51	*Strychnos nux-blanda*	Mai toum ka	Loganiaceae	1	0.67	116-185
52	*Fernandoa adenophylla*	Mai ke lao	Bignoniaceae	1	0.67	176-218
53	*Pterocarpus macrocarpus*	Mai dou	Fabaceae	1	0.67	176-218
54	*Streblus taxoides*	Mai nam khoi	Moraceae	1	0.67	176-218
55	*Buchanania siamensis*	Mouanghoamengvan	Anacardiaceae	1	0.50	116-185
56	*Dalbergia oliveri*	Mai padong deng	Fabaceae	1	0.50	116-185
57	*Calophyllum retusum*	Mai Pha ong	Guttiferae	1	0.33	124-138

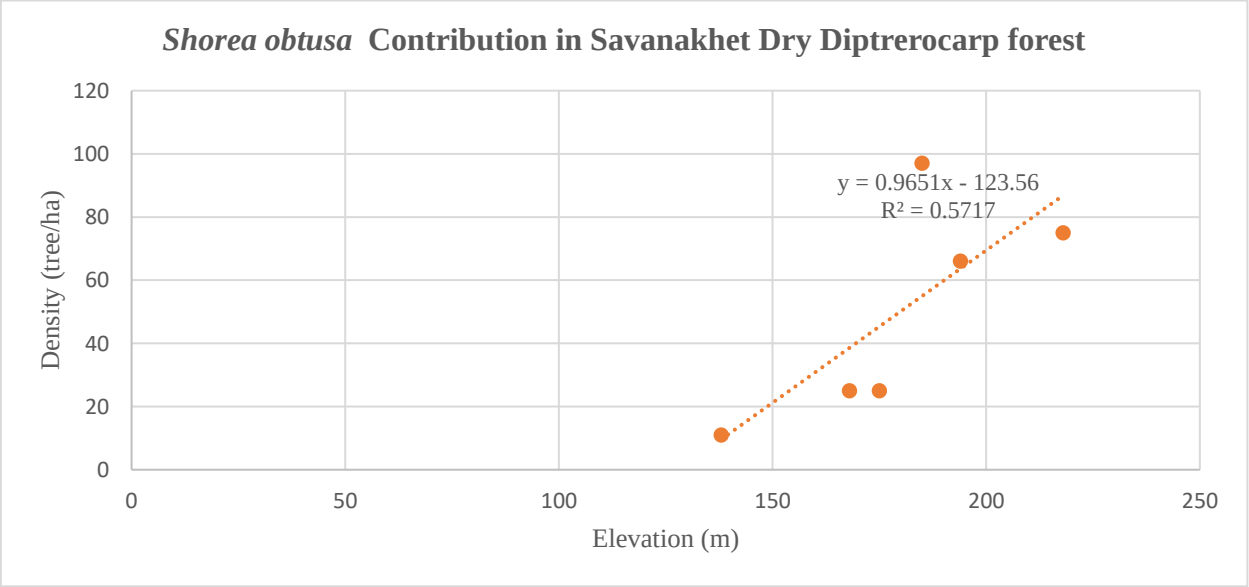

Fig 1. Relationship significantly contribution of *Shorea obtusa* in Dry Dipterocarp Forest

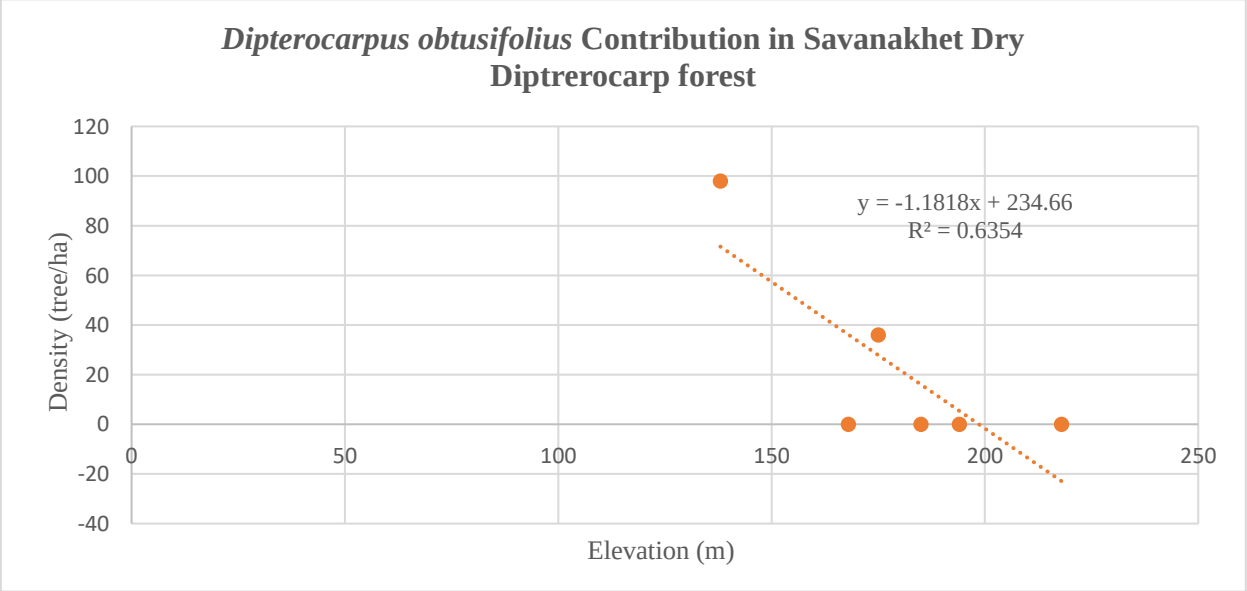

Fig 2. Relationship significantly contribution of *Dipterocarpus obtusifolius* in Dry Dipterocarp Forest

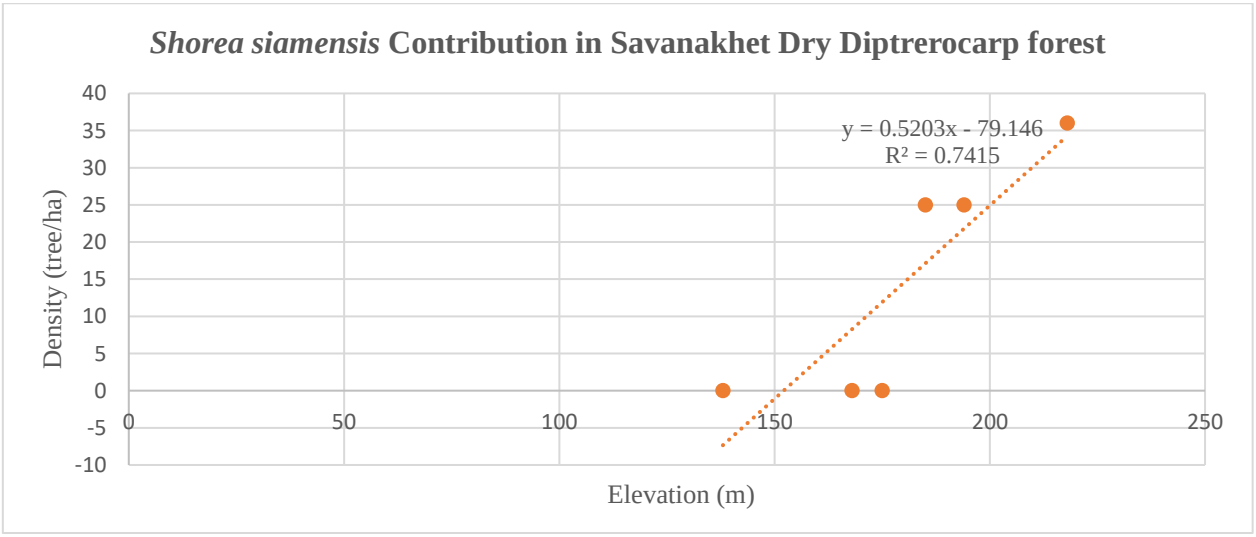

Fig 3. Relationship significantly contribution of *Shorea siamensis* in Dry Dipterocarp Forest

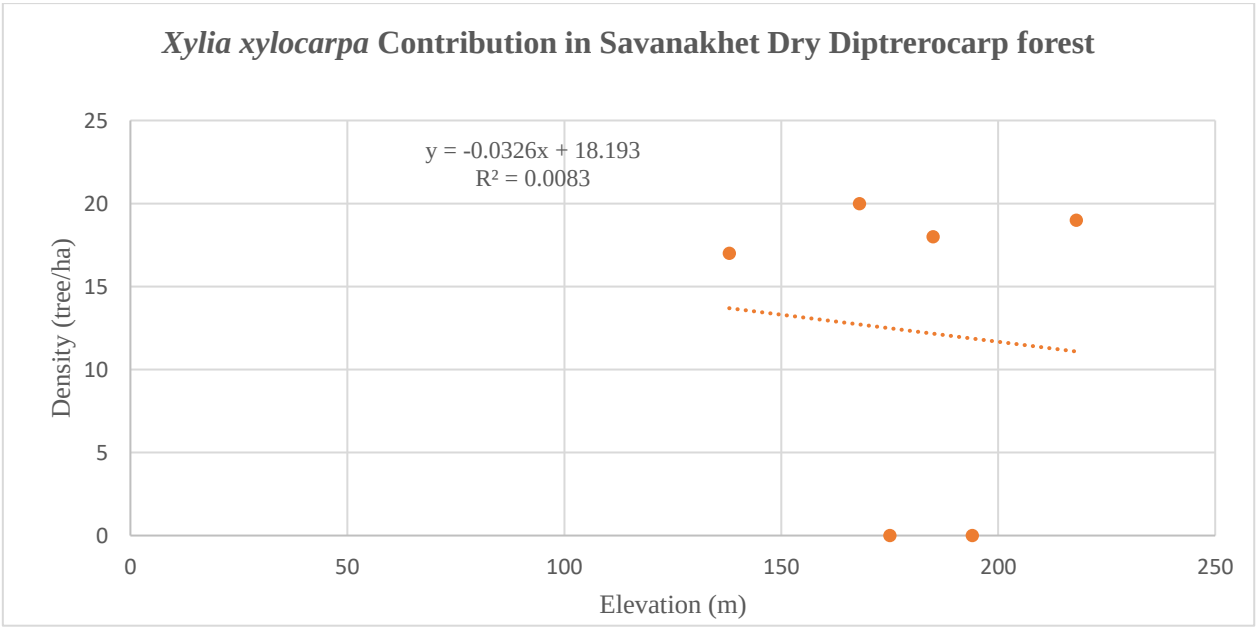

Fig 4. Relationship significantly contribution of *Xylia xylocarpa* in Dry Dipterocarp Forest

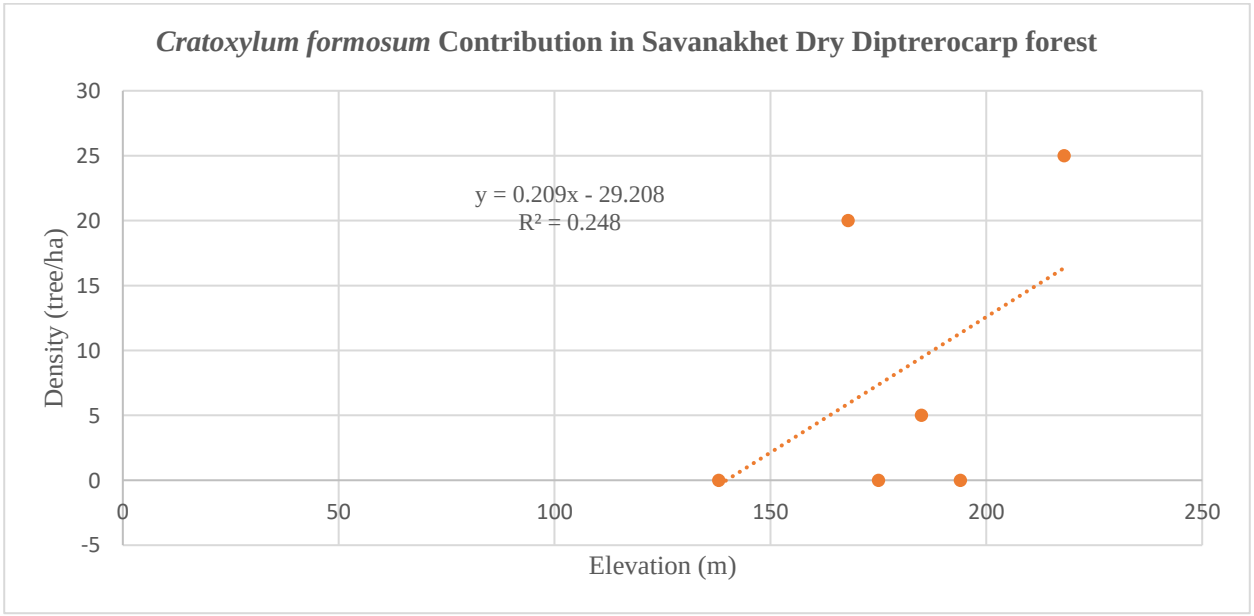

Fig 5. Relationship significantly contribution of *Cratoxylum formosum* in Dry Dipterocarp Forest

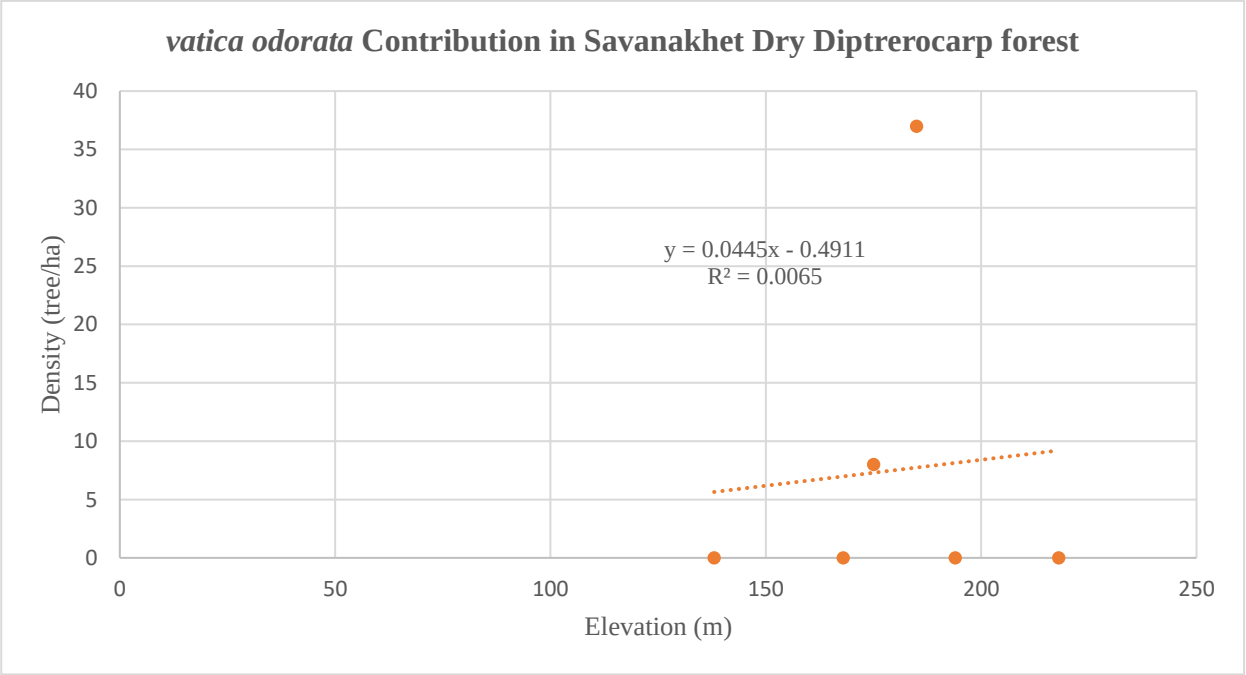

Fig 6. Relationship significantly contribution of *Cratoxylum formosum* in Dry Dipterocarp Forest