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REGULATING STOCK AND STAND STRUCTURE OF FOREST IN C 20 OF KYAUKMASIN RESERVED FOREST

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CONTENTS

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1. INTRODUCTION

A study on the feasibility of the Modified Myanma Selection System (MMSS) was initiated in 2015 in compartment 20 of Kyaukmasin reserved forest in Yedashe Township of Toungoo District. With the permission and support of the Director-General of the Forest Department, the study has been being carried out jointly by the Forest Department (FD), the Forest Research Institute (FRI) and the Ecosystem Conservation and Community Development Initiative (ECCDI). The compartment was completely enumerated in May 2015 by the students of the Myanmar Forest School (MFS) and the staff of FD and FRI. The main forest type was MUMD. Having less than 60 trees and an average basal of 46 square feet on an acre, forest density was merely 65.4% of the target growing stock of 70 sq. ft. Teak with about 5 trees and a basal area of 5.8 sq. per acre constituted 8.4% only of the entire forest while the target was set at 15%. Desirable and target stock and stand structures of the forest and of teak separately have been defined to guide future management to ensure sustainable forest resource.

The main objective of this paper is to document baseline data and findings to assist continuous research on MMSS.

2. STOCK AND STAND STRUCTURE OF FOREST

In the table below are presented the summarized complete enumeration data. *(The complete enumeration data in detail are available at the ECCDI library).*

mid class, cm	original stand		stand fitted to original(or *desirable stand structure)*		target stand (n_1)= [2.063254 * (4)]	Basal area, target stand,m^2	target minus original stand (n_1-n_0)
	number(n_0)	basal area, m^2	number	basal area, m^2			
(1)	(2)	(3)	(4)	(5)	(6)	(10)	(11)
3	644	0.455	6,615	4.676	13,649	9.648	13,005
10	10,148	79.702	4,965	38.993	10,243	80.452	95
20	5,898	185.292	3,295	103.510	6,798	213.568	900
30	4,175	295.114	2,187	154.563	4,512	318.902	337
40	2,865	360.027	1,451	182.357	2,994	376.248	129
50	1,666	327.119	963	189.095	1,987	390.152	321
60	784	221.671	639	180.710	1,319	372.851	535
70	431	165.869	424	163.236	875	336.797	444
80	221	111.087	281	141.494	581	291.939	360
90	121	76.977	187	118.846	385	245.209	264
100	69	54.193	124	97.373	256	200.905	187
110	89	84.580	82	78.192	170	161.330	81
Total	27,111	1,962	21,213	1,453	43,768	2,998.000	16,657
Per	58.81	4.2562	46.0158	3.1519	94.9423	6.503	36

acre							
Average basal area, sq. ft /ac		45.8125		33.9270		70.000	

Table 1*: The table shows complete enumeration data of all trees above "0"cm in dbh in compartment 20 (C20) of Kyaukmasin reserved forest. There were a total of 27,111 trees with a total basal area of 1,962.086 m^2 or 4.2562 m^2 per acre or 45.813 sq.ft. per acre. The distribution of the trees by diameter classes were not satisfactory, the number of trees in the smallest class being too low. So, an exponential function was fitted to the original data. The function was* $y = 7480.9\ e^{-0.041x}$ *which was assumed to be the desirable stand structure to sustain yield. The fitted stand had 33.927 sq.ft. per acre. This growing stock was very low, since some studies had shown that Myanmar natural teak bearing forests have the capacity to bear more than 100 sq. ft. per acre of trees above 2' gbh (approx. 20 cm d). See figure 1. The target growing stock in this study has been set at 70 sq.ft. per acre of all trees above '0' cm dbh. Hence, the fitted stand is raised by 2.063254 to get this target growing stock. This stand is named as* ***target stand*** *represented by the function:*

$y = 15435e^{-0.041x}$

where y is number of trees and x is diameter in cm.

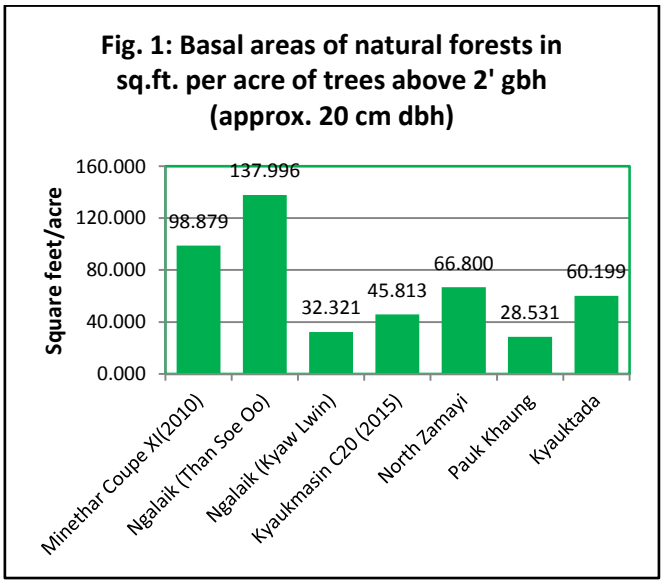
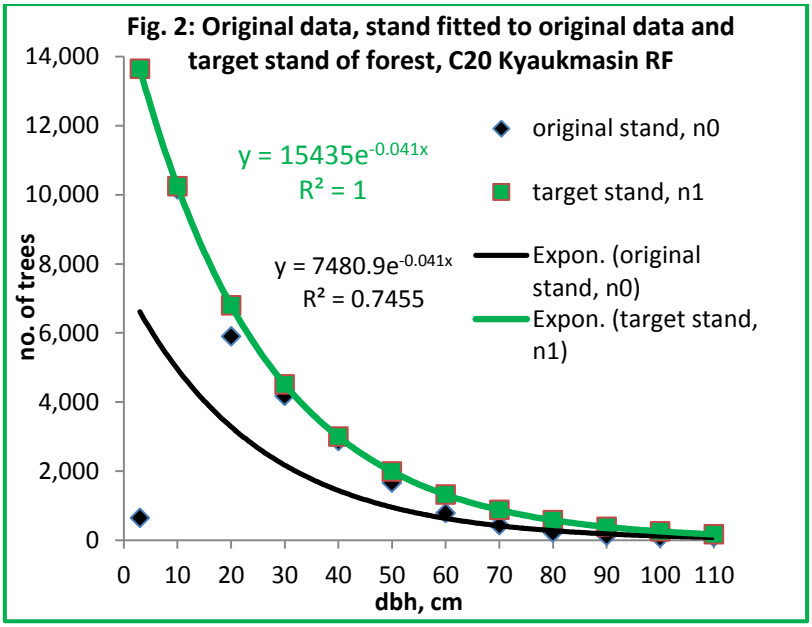


Figure 1: *Various researchers had studied the growing stocks (in terms of basal area) of natural teak bearing forests in Myanmar. Because enumerations of trees usually started from 2' gbh, the basal areas shown in the figure were most probably of all trees above two feet girth except for Kyaukmasin which included all tree species above "0" cm dbh. Pauk Khaung and Kyauktada data were derived from the permanent sample plots laid out and measured during 1981-86 National Forest Inventory conducted in the Bago Region. Basal area for N. Zamayi was quoted in the "Working Plan for North Zamayi reserve"by A.H. Barrington (1919). The simple average basal area was 67.22 sq. ft. per acre (approximately 15.431 m^2/ha).*

The fitted trends are illustrated in Figure 2 together with the original data.



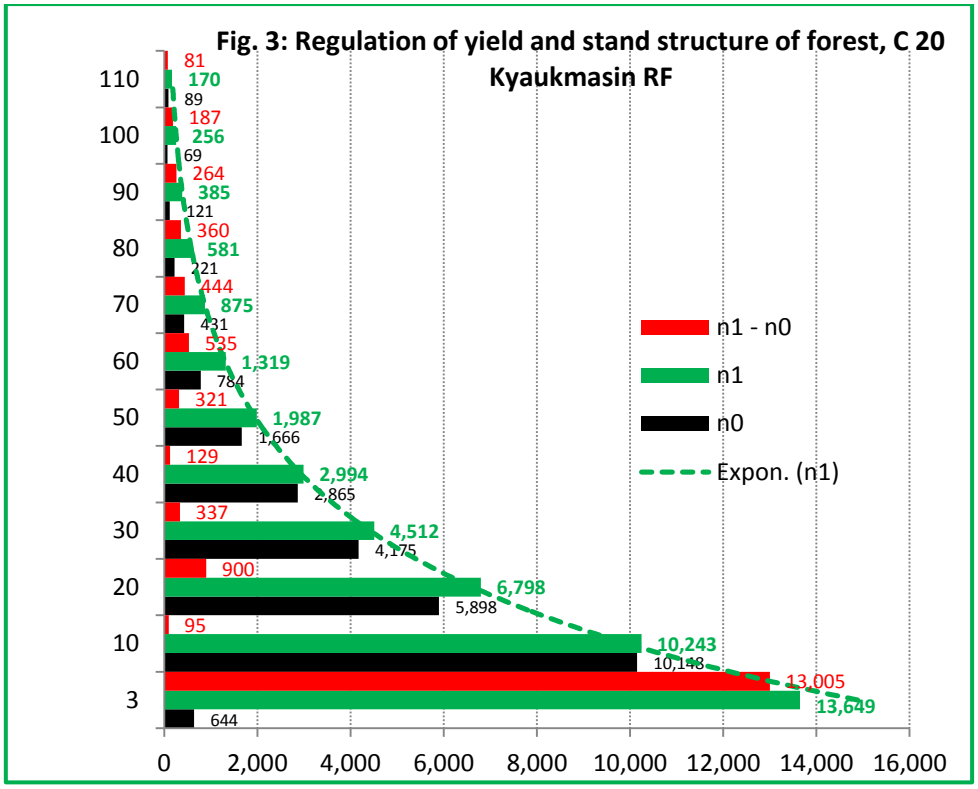
Regulating growing stock and stand structure of forest

The complete enumeration had shown that the C20 had 27,111 trees of all species above zero cm in diameter at breast height (dbh) in May 2015. A total of 169 species were recorded and they fell into species groups as shown below-

Group	No. of species	Trees in groups	
		Number	% of total
V	129	16,211	59.79
IV	13	2,411	8.89
III	7	407	1.50
II	14	3,394	12.52
I	5	2,552	9.41
0 (teak)	1	2,136	7.88
Total	169	27,111	100.00

Table 2: Distribution of trees by Groups of Species. *While TEAK constituted about 8% by number of trees, nearly 60% of the forest was occupied by species belonging to Group V.*

The original and the target forest stands are visible in Figure 3. The difference between the two sets of data is presented in column 11 of Table 1.



The target stand represents the target growing stock of the forest, i.e. 70 sq. ft. per acre.

Yield estimation

The difference of the two sets of data ($n_1 - n_0$) is the yield. Here, the target stand is much higher than the existing stand. Hence, no yield is available, but the forest must be given rest and provided with appropriate silvicultural treatments in order that it attains the target growing stock and structure as quickly as possible.

Estimating the time needed to accomplish target stock

The estimated growing stocks of the present forest and the target forest, in terms of volume, are presented in the following table (Table 3).

dbh, cm	v/tree, m^3	original stand		target stand		difference	
		n_0	V_0	n_1	V_1	(n_1-n_0)	(V_1-V_0)
3	0.001	644	0.331	13,649	7.015	13,005	6.684
10	0.067	10,148	676.872	10,243	683.237	95	6.366
20	0.159	5,898	936.013	6,798	1,078.852	900	142.840
30	0.411	4,175	1,714.673	4,512	1,852.887	337	138.215
40	0.823	2,865	2,357.036	2,994	2,463.231	129	106.195
50	1.395	1,666	2,323.570	1,987	2,771.301	321	447.731
60	2.127	784	1,667.333	1,319	2,804.454	535	1,137.121
70	3.019	431	1,301.060	875	2,641.809	444	1,340.749

80	4.071	221	899.625	581	2,364.230	360	1,464.605
90	5.283	121	639.207	385	2,036.179	264	1,396.972
100	6.655	69	459.174	256	1,702.267	187	1,243.093
110	8.187	89	728.616	170	1,389.784	81	661.168
Total		27,111	13,703.508	43,768	21,795.246	16,657	8,091.738
n/ha and Volume /ha, m^3		145	73.452	235	116.825	89	43.372
n/ac and Volume /ac, ton		59	20.996	95	33.393	36	12.398

Table 3 : The table shows number and volume of trees by diameter classes.
Tree volume was estimated using the volume function " $v = 0.0008\ d^2 - 0.0148\ d + 0.1347$", where v is tree volume over bark in m^3 and d is dbh in cm. This generalized volume function has been derived by the author based on the data from the National Forest Inventory conducted in the Bago Region during 1981-1986. Because the data range did not cover the smallest class, the volume per tree in this class was fixed arbitrarily, i.e. not by the function.

The table shows that the forest has to grow 12.398 tons/ac) to achieve the target growing stock. *If the forest as a whole could grow one cubic ton a year (assumption!)*, then it will take 12.398 years or (say) 13 years to reach the target growing stock of 33 tons or a total basal area of 70 sq. ft.
The emerging stand structures of the forest at successive stages of development should be adjusted to satisfy the desired stand structure and improve the value of the forest through appropriate silvicultural treatments.
If the basal area increment of the forest is known, it can also be used to predict the time required to achieve the desired growing stock.

3. STOCK AND STAND STRUCTURE OF TEAK

The teak stand data are presented in the following table (Table 4).

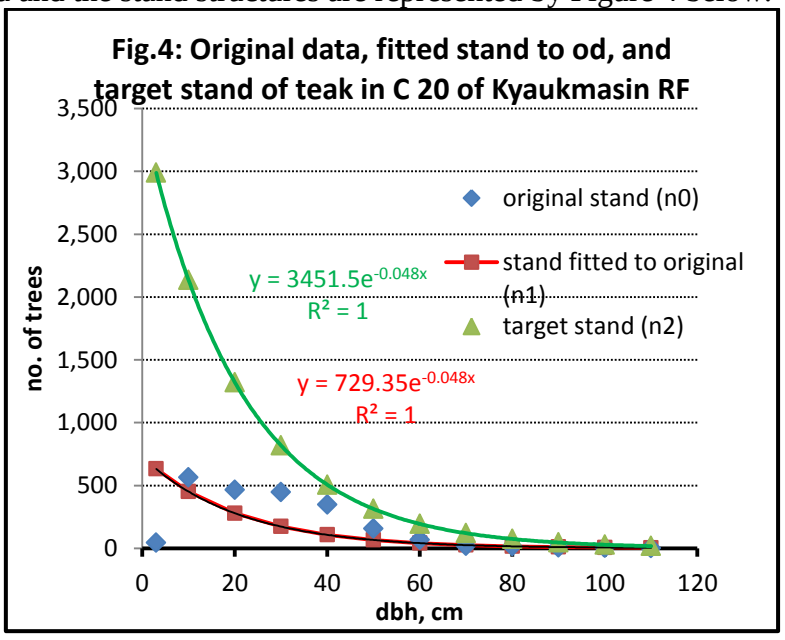
mid dbh class, cm	original stand		stand fitted to original(or *desirable stand structure)*		target stand (n_1)= [4.732277625 * (4)]	g, target stand,m^2	target minus original stand (n_1-n_0))
	number (n_0)	basal area, m^2	number	basal area, m^2			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
3	45	0.032	632	0.446	2,989	2.113	2,944
10	565	4.438	451	3.545	2,136	16.774	1,571
20	465	14.608	279	8.773	1,322	41.518	857
30	446	31.526	173	12.215	818	57.804	372
40	348	43.731	107	13.437	506	63.587	158
50	157	30.827	66	12.992	313	61.480	156
60	67	18.944	41	11.576	194	54.781	127
70	19	7.312	25	9.750	120	46.139	101
80	16	8.042	16	7.880	74	37.289	58
90	6	3.817	10	6.171	46	29.203	40

100	2	1.571	6	4.714	28	22.309	26
110	0	0.000	4	3.530	18	16.704	18
Total	2,136	164.848	1,809	95.028	8,562	449.700	6,426
Per ha (n,m2)	11.45	0.88	9.70	0.51	45.90	2.41	34
Per ac. (n. sq.ft)	4.63	3.849	3.92	5.483	18.57	10.500	14

Table 4: Teak stand tables, Compartment 20 of Kyaukmasin RF

The original teak data has been fitted by the expotential function " $y = 729.35\ e^{-0.048x}$ " which is identified as the desirable stand structure. The original and desirable stand structures are presented in column 2 and 4 respectively. The original stand had a total of 2,136 trees or 4.63 trees on an acre with a basal area of 3.849 sq.ft. Thus, the original teak stand made 8.4% of the forest by basal area (the average basal of forest was 45.813 sq. ft/ac- see Table 1). The aim has been set, in this study, for the target teak stand to constitute 15% of the forest. Hence, it should have 10.5 sq.ft per acre. As such, the desirable stand is multiplied by 4.732277625 to achieve the target teak stand which has a total basal area of 10.5 sq.ft. per acre (columns 6 and 7).The target stand can be fitted by "$y = 3451.5\ e^{-0.048x}$.

The original data and the stand structures are represented by Figure 4 below.



The original and the target growing stocks of teak are presented in the following table (Table 5).

dbh,cm	original stand volume ub		target stand volume ub	
	m^3	true ton	m^3	true ton
3	0.02	0.02	1.54	1.09
10	11.89	8.40	44.94	31.75
20	76.51	54.05	217.45	153.60
30	231.07	163.23	423.67	299.28
40	391.21	276.35	568.83	401.82

50	312.27	220.59	622.77	439.92
60	207.23	146.39	599.26	423.32
70	83.60	59.05	527.50	372.63
80	93.83	66.28	435.03	307.31
90	44.62	31.52	341.35	241.13
100	18.13	12.81	257.52	181.91
110	0.00	0.00	188.20	132.95
Total	1,470.37	1,038.67	4,228.07	2,986.71
Per ha	7.88	5.57	22.66	16.01
Per acre	3.19	2.25	9.17	6.48

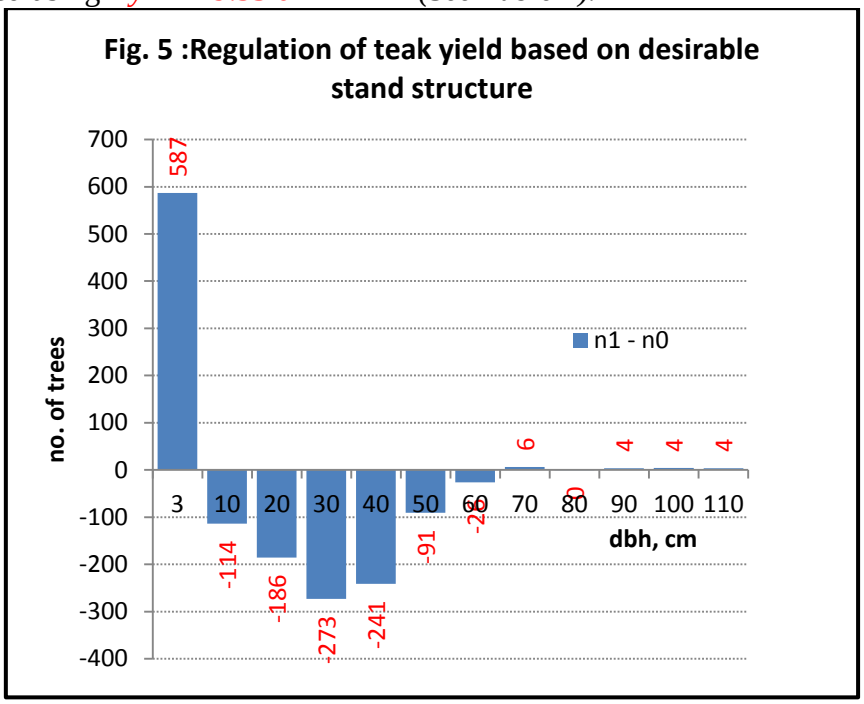
Table 5: Growing stock of teak in the forest of C20, Kyaukmasin RF.
*The volume function used is " v = 0.0000166 $d^{3.1616}$*0.9866^{d}" developed by the author for planted teak. It was used here because more appropriate function was not available.*

As seen in the table, the original teak stand had the total growing stock of 1,039 true cubic tons (1,470 m^3) or 2.25 tons per acre(7.88 m^3 per ha). The target teak stand is expected to have a total growing stock of 2,987 true cubic tons (4,228 m^3) or 6.48 tons per acre (22.6 m^3 per ha).

Estimating the yield of teak

The inventory data had shown that the growing stock of teak was very low with only 3.849 sq. ft. on an acre (see Table 4 above) forming 8.4% only of the entire forest. The target of teak composition under MMSS being 15%, the present growing stock should be enhanced through effective protection and improvements.

If the harvest is required, the yield can be estimated by simply comparing the original stand with the desirable residual stand as shown in Figure 5 below. The desired residual stand has been estimated using *" $y = 729.35\ e^{-0.048x}$ "* *(See Table 4).*



In Fig.5 the negative numbers indicate number of trees that can be extracted. The positive figures are the numbers of trees needed to make up the desirable residual stand. Thus, the estimated yield is as shown in Table 6 below.

dbh,cm	no. of yield	v/tree,m^3	Total volume ub m^3	True

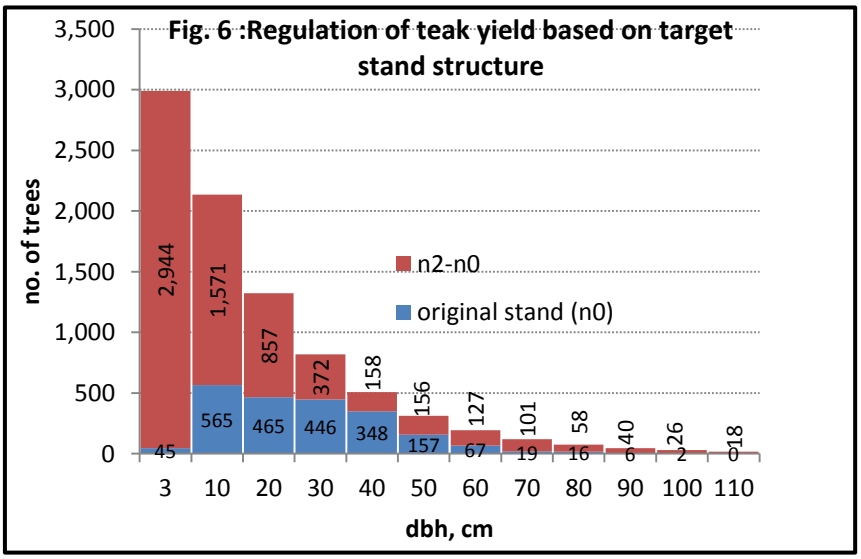
	trees			ton, ub
5-15	114	0.021	2.39	1.69
15-25	186	0.165	30.56	21.59
25-35	273	0.518	141.54	99.98
35-45	241	1.124	271.00	191.44
45-55	91	1.989	180.67	127.62
55-65	26	3.093	80.60	56.93
Total	931	-	706.76	499.26

Table 6: *Possible yield of teak (1 m^3 = 0.7064 true ton)*

The total possible yield of teak is 931 trees of about 500 true cubic tons ub (under bark). The MMSS does not prescribe exploitable size. Trees could be extracted if they are profitable commercially or if they need to be removed to improve the residual stand.

Regulation of yield based on target stand structure

The target stand structure of teak is very much higher than the existing one (see column 8 of Table 4 and Fig. 6). Once the target stand structure is achieved teak is expected to constitute



15% of the teak-bearing forest in terms of basal area. So, the present existing teak trees should not be cut, but their population and quality improved by all possible means.

Stand structures by Species Groups

See APPENDIX

4. CONCLUSIONS AND RECOMMENDATIONS

- The composition of teak in the research forest was about the average considering the general situation of the forests at present in the country.
- However, since the growing stock of the study forest was very low, it should be raised to a certain level. The recommended target is 70 square feet per acre or about 15 m^2/ha.

- Accordingly, the density of teak has to be enhanced as well to occupy about 15% of the forest.
- In view of this, the forest must be given rest, providing appropriate treatments, regulating the harvests, when they are due, to achieve the set desirable stand structures of both teak and the entire forest.
- Because the research on the new approach to forest management is long-term, treatments should be started promptly, not to lose valuable time, and effectively.
- Most importantly, effective protection of the experimental site (i.e. Kyaukmasin RF) is crucial.

ACKNOWLEDGEMENT

- Many forest officers and students from the MFS had taken part in the field work of the pilot project. I would like to extend my sincere thanks to them and to Dr. Thaung Naing Oo, Director of FRI, who has been enthusiastically coordinating the project, and his staff involved in the process.

- Without the official, technical and financial support of Dr. Nyi Nyi Kyaw, Director-General of the FD, this research project is impossible. I appreciate his support very much.

- The study will take not a couple of years but decades. With this in mind, I would like to earnestly request successive FD directors-general and FRI directors to continue the research, and if possible to practice it - may be on a small scale- in other forests. In this perspective, I offer a heartfelt gratitude to you all in advance.

December 23, 2017 Yangon

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APPENDIX: STAND STRUCTURES OF SPECIES GROUPS