Forest Stand Dynamics of Compartment 82 and 84 in Kabaung Reserved Forest, Oaktwin Township, Bago Region

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Abstract

Studies of forest stand dynamics in the Kabaung Reserved Forest, two permanent plots (100 m x 100 m) in two different sites were set up during November 2016. Each plot was subdivided into 100 (10 m x 10 m) subplots. The second enumeration on the two plots was performed during October 2019. Every tree was inspected and if it was alive, gbh was measured. Trees that were not recorded previously but reached gbh of ≥ 10 cm were recorded as new recruits. Changes in population size per time interval are a constant proportion and calculated mean annual rates of mortality (M) and recruitment (R) was using based on calculated as Sheil, (1995), Sheil and May (1996) and Gomes *et al*., (2003). The rate of net changes in full period, for both number of individuals (Ch_N) is used the equation based on Oliveria Filho *et al*., (1997) and Werneck and France Schineli (2004). Tree mortality and recruitment are key factors influencing forest dynamics. The mean annual mortality rates the lower was compartment 84 (1.46 $\%y^{-1}$) although the higher mortality rate can be seen in the compartment 82 (1.96 $\%y^{-1}$). The recruitment rate of compartment 82 (1.35 % y^{-1}) was lower than the compartment 84 (2.51 % y^{-1}). The rate of net changes in compartment 82 and 84 were 3.24 % $y^{-1}$and -1.61 % y^{-1}at second census. During the present investigation, mortality rate, recruitment rate, and the rate of net change of the forest stand were understood. These findings have strong implication for sustainable forest management and conservation for tropical deciduous forest.

Introduction

Studies of forest dynamics, i.e., the changes of forest composition and structure over time, have received much scientific attention since the early concepts of forest succession (Clements 1916). Marking counting and measuring individuals and periodically re-counting these individuals to population changes common practice for ecological studies (Krebs 1999). Secondary forest succession has been described as the colonization and replacement of functional groups of species, which differ in life history attributes. such as, requirements, growth rates size at maturity. (Bazzaz 1996). Demographic studies in plant population provide useful information on population dynamic and also be used to examine the biotic and abiotic factors affecting the plant population dynamic.

A tropical forest is a complex and dynamic biotic community, which has power of self-maintenance through regeneration. Almost all organisms, mortality is high in the early stages of life, so that the selection of survivors and the determination of species composition of the forest operate most strongly in young plants; hence the importance of the regeneration. (Grubb, 1977).

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Study area

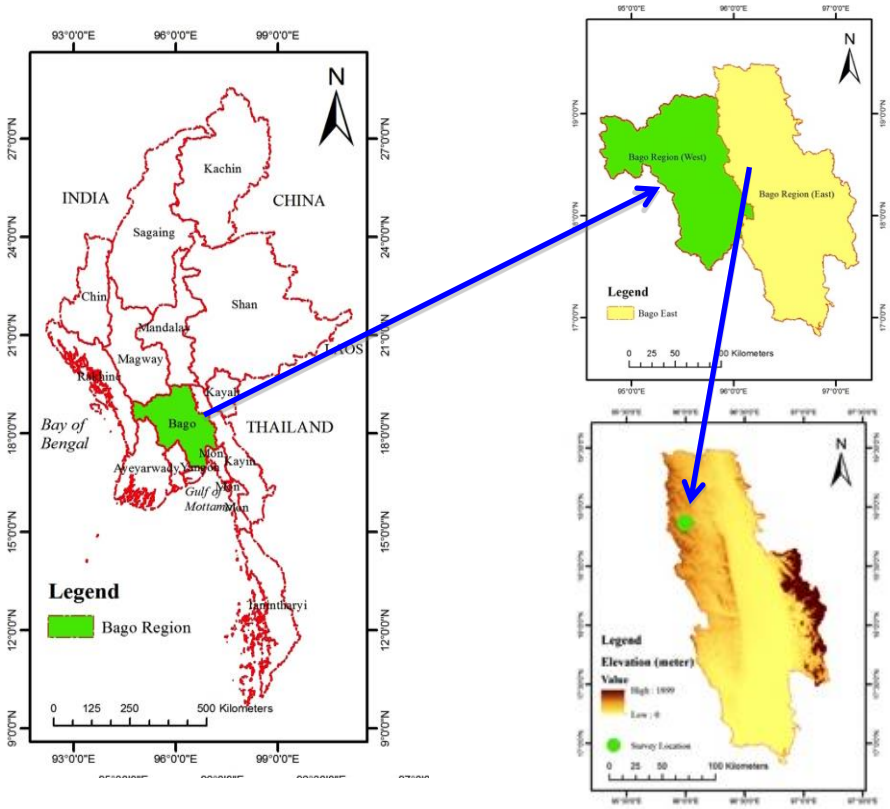

Fig. 1. Location map of Study Area

The Study Area is situated in West Bago Yoma of Oaktwin Township in Bago region. It covers an area of 7762.57 ha (19182 Acres) and this area encompasses hills, plains, slopes, valleys, cascades and creeks.The compartment 82 is occupied 224.19 ha (554 Acres) altitude between N 18° 52' 08.6" to N N 18° 52" 11.0' & E 96° 00'28.3" to E 96° 00'26.0' , elevation ranges between 253m to 290m.The compartment 84 is occupied 224.19 ha (554 Acres) altitude between N 18° 52' 08.6" to N N 18° 52" 11.0' & E 96° 00'28.3" to E 96° 00'26.0' , elevation ranges between 253m to 290m. The location of the study sites is shown in (Fig.1.)

Climate

The climate of the study area is relatively warm in summer, moist in monsoon and cold in winter. The general climate has been classified as "tropical", with a seasonal variation in temperature and rainfall. Temperature, rainfall, humidity and windspeed data from 2016 - 2019 were assembled in Taungoo station, nearest station of the study area. (Source: Department of Meteorology and Hydrology, Bago Towinship, Bago Region).

The climate of Kabaung Reserved Forest has three main seasons; extremely hot summer, moist monsoon and cool winter. The monthly rainfall ranges from 0 mm in February and March to 545 mm in July in 2016 and 0 mm in February, March, April to 701 mm in July in 2019.Moreover, the minimum and maximum temperature range varies 2016 and 2019 from 15.4 ºC in January to 38.6 ºC in March as well as 12.8 ºC in January to 38.6 ºC in April. The monthly relative humidity ranges from 63% May to 92% July and August in 2016 and 67% March and April to 92% July and August in 2019.

Table 1. Monthly Mean Temperature (ºC)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2016	23.1	26.2	30.3	33.3	31.0	27.6	27.1	27.3	27.9	28.5	26.8	25.7
2017	24.2	26.0	29.3	30.8	31.5	27.7	26.8	27.1	27.3	26.8	26.7	23.9
2018	23.6	25.5	28.8	31.2	29.6	26.9	26.4	26.4	27.6	27.4	25.8	24.7
2019	23.3	25.9	27.8	31.3	33.3	30.7	28.2	27.4	28.6	29.6	26.7	24.3

Table 2. Monthly rainfall (mm)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2016	10	0	0	7	259	306	456	279	256	198	59	0
2017	23	0	1	47	138	470	377	409	280	315	18	0
2018	17	0	0	19	213	418	506	545	162	123	4	4
2019	18	0	0	0	27	215	701	490	409	73	18	0

Table 3. Monthly relative humidity (%)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2016	76	67	67	65	63	89	92	92	91	89	86	80
2017	75	72	64	70	73	89	92	93	94	92	86	78
2018	79	72	72	68	77	87	92	93	89	87	84	82
2019	78	70	67	67	70	81	92	92	91	85	84	80

Soil

Soil is one of the chief factors determining the productive potential of the area concerned. The soil on the mountain ranges were relatively thick and little rocky but thin on the steep slopes of the ranges. Soil of this area consists of black gravelly sandy loam to loamy sand in natural, sometimes underlined by rock strata. Morphologically, they were characterized by yellowish-brown to dark brown color.

Collection and analysis of soil sample

Soil sample were collected from soil depths of 0-10 cm, all selected points of each study plots. Different soil samples were collected for the tested of soil physical and chemical properties. Soil samples were analyzed in the soil laboratory of the Department of Agriculture Research, Yezin, Myanmar for their texture, nutrient contents (N, P, K), soil pH, Mg, Na and organic carbon. The data of soil tested were shown in table 2.

Table 4. Soil characteristic in study area

No.	Study area	Texture Name	pH	Total Nitrogen (%)	Organic Carbon (%)	P (mg/kg)	K (mg/kg)	Ca Cmoc/kg)	Mg Cmoc/kg)	Na Cmoc/kg)
1	Compartment 82	Sandy Loam	6.97	0.07	1.29	1.5	189	2.21	4.76	0.17
2	Compartment 84	Sandy Loam	6.26	0.05	1.08	2	161	3.55	5.85	0.12

Topography

The study area was generally characterized by rough topography with mountains, deeply valleys, escarpments, plains, slopes, cascades and creeks.

Methodology

Plot set up and first census data collection

To understand the dynamic of plant species in the Kabaung Reserved Forest, two permanent plots (100 m x 100 m) in two different sites (Compartment 82 and 84) were set up and observed during November 2016. Each plot was subdivided into 100 (10 m x 10 m) subplots. Subplots were labeled by 10 rows with letter and 10 columns with numbers as shown in Fig. 2.

In November 2016, 2 permanent plots with a total area of 2 hectare were first census within the area of Kabaung Reserved Forest. In each plot, all live individuals with girth at breast height ≥ 10cm gbh 1.3 m from the ground were measured and identified with Hundley and Chit Ko Ko, 1961 and Kress et al., 2003.In October 2019, all surviving live trees were measured following the original 2016 protocol, including deaths and all new recruits that had reached the minimum size 10 cm.

100 m

J 1	J 2	J 3	J 4	J 5	J 6	J 7	J 8	J 9	J 10
I 1	I 2	I 3	I 4	I 5	I 6	I 7	I 8	I 9	I 10
H 1	H 2	H 3	H 4	H 5	H 6	H 7	H 8	H 9	H 10
G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	G 10
F 1	F 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10
E 1	E 2	E 3	E 4	E 5	E 6	E 7	E 8	E 9	E 10
D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10
C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10
B 1	B 2	B 3	B 4	B 5	B 6	B 7	B 8	B 9	B 10
A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10

0 m 100 m

Fig. 2. Set up of main plots at study area and 10m x 10m subplots are shown with their labels

Data Analysis

Mean annual rates of mortality and recruitment

Changes in population size per time interval are a constant proportion and calculated mean annual rates of mortality (M) and recruitment (R) was using based on calculated as Sheil, (1995), Sheil and May (1996) and Gomes *et al*., (2003).

$$M = \left\{1 - \left[\frac{(N_O - m)}{N_O}\right]^{\frac{1}{t}}\right\} \times 100$$

$$R = \left\{\left[\frac{(N_O + r)}{N_O}\right]^{\frac{1}{t}} - 1\right\} \times 100$$

Where, M = the annual rates of mortality

N_O = the initial population count

m = the number of deaths

r = the number of recruits

t = the length of time interval

The rate of net changes

The rate of net changes in full period, for both number of individuals (Ch_N) is used the equation based on Oliveria Filho *et al*., (1997) and Werneck and France Schineli (2004).

$$Ch_N = \left\{\left[\frac{(N_O - m + r)}{N_O}\right] - 1\right\} \times 100$$

Where, Ch_N = the rates of net changes in full period

N_O = the initial population count

m = the number of deaths

r = the number of recruits

Size classes

Analysis within different size was performed on the following gbh limits:

≥10 cm gbh (≥3.2 cm dbh) = all trees

10 ≤ 50 cm gbh (3.2 cm – < 15.9 cm dbh) = small tree

51 ≤ 100 cm gbh (16.21 cm – < 31.8 cm dbh) = medium tree

> 100 cm gbh (>31.8 cm dbh)= large tree

RESULTS

Table 5. Tree numbers in two plots at the start and end of the period 2016 to 2019

	Period 2016-2019	
	Compartment 82	Compartment 84
n_{start}	560	432
n_d	31	18
n_{rec}	22	32
n_{end}	551	446

n_{start} = number of all trees at start, n_d = number of dead trees,

n_{rec} = number of recruits, n_{end} = number of all trees at end.

Tree numbers

The compartment 82 in November 2016, consisted of 560 trees with a gbh of ≥10 cm. In October 2019, 31 trees were recorded as dead. A total of 22 new trees were recruited into the population (i. e. reaching ≥10 cm gbh) were recorded.

The compartment 84 in November 2016, consisted of 432 trees with a gbh of ≥10 cm. In October 2019, 18 trees were recorded as dead. A total of 32 new trees were recruited into the population (i. e. reaching ≥10 cm gbh) were recorded.

According to the result of the second census compartment 84 had more recruits than the compartment 82 and compartment 82 had more dead than the compartment 84 (Table 5).

Tree diversity

Table 6. Diversity measures for the two main plots at two censuses in different size classes, showing number of tree (n), species richness (S), diversity (Shannon index H) and evenness (E)

Size class	year	Compartment 82					Compartment 84				
		n	S^	H	D	E	n	S^	H	D	E
all	2016	560	48.92	4.29	0.90	0.77	432	61.80	4.65	0.93	0.78
	2019	551	48.90	4.28	0.90	0.77	446	59.82	4.67	0.93	0.79
small	2016	265	37.98	4.32	0.92	0.83	219	44.90	4.33	0.90	0.79
	2019	226	37.96	4.36	0.93	0.84	217	44.92	4.29	0.90	0.79
medium	2016	194	33.97	3.49	0.83	0.69	110	29.96	4.08	0.92	0.84
	2019	200	32.97	3.58	0.83	0.72	118	30.98	4.10	0.92	0.84
large	2016	101	25.97	3.51	0.84	0.75	103	28.92	3.97	0.90	0.83
	2019	125	27.97	3.64	0.87	0.77	111	29.91	4.04	0.91	0.83

The compartment 84 in November 2016, consisted of 61 species and in October 2019 consisted of 59 species. Two species were disappeared in compartment 84, *Croton roxburghianus* N.P Balkr. (thatyingyi) and *Wendlandia glabrata* DC (thit phyu) respectively. Species composition was not changed in compartment 82.

Although the total number of individuals increased steadily in compartment 84 decrease in compartment 82 between the first and second census, neither Shannon's H nor Evenness changed notably for all trees. Among the two study sites, compartment 84 possesses higher diversity value (H = 4.65, 4.67 and D = 0.93, 0.93), than compartment 82 (H = 4.29, 4.28 and D = 0.90, 0.90), within first and second census. A higher diversity value occurred in the second census in compartment 82 and compartment 84 for all size classes (Table 6).

Mortality and recruitment

Table 7. Rate of morality and recruitment in the two main plots at 2016 to 2019

	2016-2019	
	Compartment 82	Compartment 84
m_a (%y^{-1})	1.96	1.46
r_a (%y^{-1})	1.35	2.51

m_a = annual mortality

r_a = annual recruitment

Fig. 3. The annual rate of mortality and recruitment in the study plots

The annual mortality rates of the compartment 82 and 84 were (1.96 %y^{-1}) and (1.46 %y^{-1}) respectively. The mean annual mortality rates the lowest was compartment 84 (1.46 %y^{-1}) although the higher mortality rate can be seen in the compartment 82 (1.96 %y^{-1}) (Table 2.8 Fig. 2.6). The mean annual recruitment rates of the compartment 82 and 84 were (1.35 %y^{-1}) and (2.51 %y^{-1}) respectively. The recruitment rate of compartment 82 (1.35 % y^{-1}), was lower than the compartment 84 (2.51 % y^{-1}) (Table 7 Fig. 3).

Mortality in size classes

Table 8. Number of mortality rate in size classes from 2016 to 2019

Size class	Compartment 82			Compartment 84		
	n_{16}	n_{d19}	m_a (%y^{-1})	n_{16}	n_{d19}	m_a (%y^{-1})
10-20	106	67	5.54	64	60	1.65
21-30	46	65	2.32	61	63	2.93
31-40	55	34	0.64	50	48	0.70
41-50	58	60	1.22	44	46	1.60

Size class	Compartment 82			Compartment 84		
	n_{16}	n_{d19}	m_a (%y^{-1})	n_{16}	n_{d19}	m_a (%y^{-1})
small	265	226	2.97	219	217	1.77
medium	194	200	1.27	110	118	1.28
large	101	125	0.69	103	111	1.02

n_{16} = number of tree in 2016, n_{d19} = number of deaths in 2019

m_a = annual mortality

Annualized mortality was calculated for three main size classes (small, medium and large trees) and additionally the class of small trees was subdivided into 10 cm classes; this was not applied to medium and large trees, because tree numbers were low in these size classes. In compartment 82 and 84, m_a was higher for small sized trees (2.97 %y^{-1} and 1.77 %y^{-1}). In compartment 82 and 84, m_a was lowest for large sized trees (0.69 %y^{-1} and 1.02 %y^{-1}). Within the small size classes 10-20 cm and 21-30 cm sized classes mortality was higher m_a and in compartment 82 and compartment 84., 21-30 cm and 31-40 cm sized classes mortality was higher m_a and in the 31-40 cm size class classes mortality was the lowest in the compartment 82 and compartment 84 (Table 8).

The Net Change of individuals in the study area

Table 9. The net changes of total individual in the study plots

	Compartment 82	Compartment 84
Total individual of first census	560	432
Total individual of end census	551	446
No. of mortality	31	18
No. of recruitment	22	32
The net changes	-9	+14

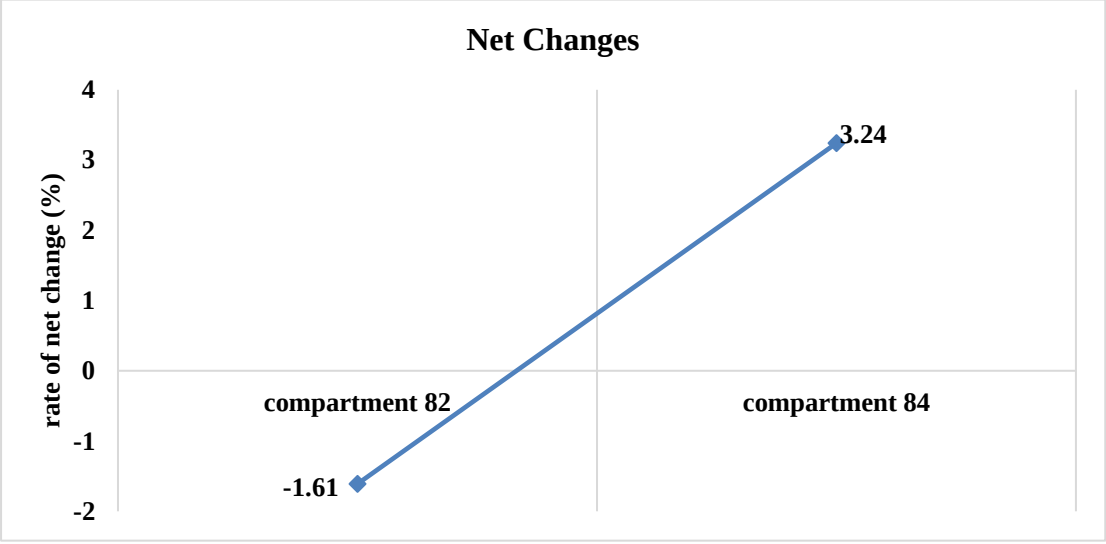

Fig. 4. The rate of net change population in the study plots

In compartment 82, the total individual species of 560 n ha^{-1} was recorded at first census. There was individual species of mortality was 31 n ha^{-1} and recruitment was 22 n ha^{-1} in second census. The total individual species of 551 n ha^{-1} was recorded in 2019. The net changes of individual species in the compartment 82 was decreased 9 n ha^{-1} at second census. In compartment 84, the total individual species of 432 n ha^{-1} was recorded at first census. The number of individual species of mortality was 18 n ha^{-1} and recruitment was 32 n ha^{-1} in second census. The total individual species of 446 n ha^{-1} was recorded in 2019. The net changes of individual species in the compartment 84 was increased 14 n ha^{-1} at second census (Table 9). The rate of net changes in compartment 82 and 84 were 3.24 % and -1.61 % at second census. (Fig. 4).

Discussion and Conclusion

In this study, a total of 997 trees in a total area of 2 ha were visited in 2019. The stem density of October 2019 was 551 n ha^{-1}in compartment 82 and 446 n ha^{-1} in compartment 84 respectively.The two species were disappeared in compartment 84, *Croton roxburghianus* N.P Balkr. (thatyingyi) and *Wendlandia glabrata* DC (thitphyu) respectively. Species composition was not changed in compartment 82.

The annual mortality rate (m_a) of all trees was 1.96 %y-1 in compartment 82 and 1.46 %y-1 in compartment 84. The main reasons for mortality in the sample plots were falling of old trees into small trees, the making larges nests and feeding on wood by termites. Human disturbances like illegal cutting, fire wood collection were not seen in the sample plots.Generally, the small size classes, 10-20 cm, 21-30 cm and 41-50 cm showed the higher mortality rate than other size class in compartment 82. The small size classes, 10-20 cm, 21-30 cm showed the higher mortality rate than other size classes in compartment 84. The higher mortality rates recorded in the smaller individual may be accounted for by the reduce resistance of their thinner bark (Hoffmann *et al*., 2012).

Annualized recruitment was calculated for all trees (≥10 cm gbh). The rate of recruitment was about two times higher than the mortality rates in compartment 84 (m = 1.46 % y^{-1}, r = 2.51 % y^{-1}). Recruit rates differed among plots in the second census, the higher rates of recruitment recorded in compartment 84 (2.51 % y^{-1}) although the lowest rates recruitment was compartment 82 (1.35% y^{-1}). Although numbers of recruited trees were higher than dead trees in compartment 84, the diversity index in 2019 was slightly higher. An explanation of this lies in the strong dominance by a few species, as a result of which the numerical influence of the recruitment of new species was low.

The net changes of density 14 individual species increase in the compartment 84 although 9 individual species decrease in the compartment 82. By the present study result, the regeneration within compartment 82 shows the potential for recovery of the forest vegetation with the help from protection measures. Studies of tree forest dynamic are critical to increasing understanding of the conservation needs of tropical forest ecosystem (Hubbell and Foster, 1992 and Sheil *et al*., 2000). During the present investigation, the floristic composition, diversity, mortality rate, recruitment rate, and the rate of net change of the forest stand were understood. These findings have strong implication for sustainable forest management and conservation for tropical deciduous forest.

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