

RAPID BIODIVERSITY SURVEY REPORT – V

Assessment of Biodiversity



Sikkim Biodiversity Conservation and Forest Management Project (SBFP)

Forest and Environment Department

Government of Sikkim

2019

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Dendrobium chrysanthemum

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2019



Cardiocrinum giganteum

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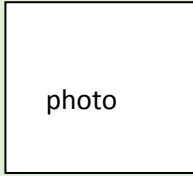
Forest and Environment Department,

Government of Sikkim,

Deorali, Gangtok - 737102, Sikkim, India

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MESSAGE

Sikkim is well known world over for its rich biodiversity, cultural uniqueness and environmental conservation initiatives. The State also has a rich history of being a much visited place for botanical explorations in the past.

Rapid Biodiversity Survey – V *Assessment of Biodiversity* is one of the series of publications on Biodiversity of Sikkim showcasing its richness in some parts of the reserved forests of Sikkim. I am happy to know that these publications have been providing better baseline data on biodiversity for management plans of protected areas and working plans for rest of the forest areas.

We are grateful to Japan International Cooperation Agency (JICA) for facilitating the study on biodiversity of Sikkim and compilation of such scientific data. I wish the Forest and Environment Department all the success in their future endeavours and await the publication of the complete series.

Prem Singh Tamang

PREFACE

Biodiversity Conservation is one of the major components under JICA-assisted Sikkim Biodiversity Conservation and Forest Management Project (SBFP) and inventorization of biodiversity is the main activity undertaken to collect the baseline data on biodiversity for betterment of conservation initiatives, policy decisions, future reference and monitoring.

So far, four publications of Rapid Biodiversity Survey Report I, II, III & IV have been published which portrays the biodiversity found in most of the Protected areas and Reserve Forests in Sikkim.

The present compilation is one of the series in Biodiversity publication based on Rapid Biodiversity Survey studies done in few parts of Reserve Forests. We are happy that these scientific databases are being utilized for better management of forest & wildlife in Sikkim.

We are also hopeful that a strong linkage can be built between these scientific studies, management practices and livelihood of the people.

Shri M. L. Srivastava, IFS
Principal Chief Conservator of Forest-cum-Principal Secretary,
Sikkim Biodiversity and Forest Management Project,
Forest and Environment Department
Government of Sikkim

FOREWORD

I am delighted to present the fifth edition of Rapid Biodiversity Survey Report – V published under Sikkim Biodiversity Conservation and Forest Management Project (SBFP, JICA). The first edition (RBS Report – I) was published in 2015 on an inventory of biodiversity followed by the subsequent series II, III and IV.

This publication is a compilation of assessment of scientific data collected during the survey conducted in various Reserve Forests of Sikkim. It is my hope and expectation that this book will provide a constructive understanding to the scientific data on biodiversity for students and researchers.

In addition to providing a practical resource containing the core scientific analysis of biodiversity, this book is designed to serve as a resource of biodiversity in the state and an interdisciplinary document that recognizes the availability and occurrence of both the floral and faunal species.

I sincerely congratulate and wish the Sikkim Biodiversity Conservation and Forest Management Project (SBFP) team all success in its efforts to publish the series on Biodiversity of Sikkim.

Shri. Nima Wangdi Tamang (IFS)

Project Director

Sikkim Biodiversity Conservation and Forest Management Project – JICA

Forest and Environment Department

Government of Sikkim

ACKNOWLEDGEMENT

This book titled “Rapid Biodiversity Survey Report – V *Assessment of Biodiversity*” is a compilation of study reports of Rapid Biodiversity Survey works done in various Reserve Forests of Sikkim and is one of the series in Rapid Biodiversity Survey publications. We are hopeful that this compilation will be useful for Forest Managers, Researchers, Students and Policy makers as well.

The making and compilation of this book consumed a lot of hard work, research and dedication. On behalf of Sikkim Biodiversity Conservation and Forest Management Project, Forest and Environment Department, Government of Sikkim, I would like to acknowledge the significant contribution to the following institutions and individuals without whose support and guidance would not have been possible in making this a success.

Firstly, we are thankful to Japanese International Co-operation Agency for their support and for providing necessary guidance concerning project implementation. We are grateful to the Government of Sikkim for their support and encouragement in publishing such scientific reports. We are also grateful to the Survey Team of SBFP for compilation of this report with dedication, competence, diligence and hard work in the field; and a big thanks to GIS SBFP.

We would also like to extend our humble and sincere gratitude to Shri. Mukund Lall Srivastava (IFS), Pr. Secretary-cum-PCCF and Shri Nima Wangdi Tamang (IFS) CCF-cum-Project Director, SBFP for their continuous guidance and encouragement in our endeavour.

Divisional Forest Officer
Sikkim Biodiversity Conservation and Forest Management Project
Forest and Environment Department
Government of Sikkim

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INTRODUCTION

Forest is considered as one of the richest and natural resources of Sikkim covering 47.62% (3379 sq.km.) of the total geographical area (7096 sq.km.) of the State. The biological diversity of Sikkim is well-known for its enormously rich biodiversity and has been recognized as India's first Mixed World Heritage Site on UNESCO World Heritage list and as the Himalayas' hotspot region. The diverse eco-climatic conditions and wide altitudinal variation from sea level to the highest mountainous ranges in the world manifests the state with over 9000 plant diversity and over 15000 faunal diversity. Over 5500 flowering plant species, 557 orchids, 38 rhododendrons, 16 conifers, 28 bamboos, 362 ferns and its allies, 9 tree ferns, 30 primulas, 11 oaks, 1681 medicinal plants, 144+ mammals, 568 birds, 48 fishes, and over 689 butterflies' species form the biodiversity of the State. In addition, few areas of the State exhibit endemic species and experience loss of habitat of some threatened plant species. Exploration of our floral and faunal wealth is a foundation for understanding the forest ecology and in sustaining human development by determining the status of our ecosystem and aid in formulating approaches towards conservation of our biological diversity.

There have been a large number of contributions to the knowledge on the biodiversity of Sikkim Himalaya by the pioneer British Botanist, Sir Joseph Dalton Hooker, who made historical records on the floral diversity of the State and described Sikkim as the "Botanists' Paradise". Several European Botanists notably Sir George King, Charles Baron Clarke, Sir David Prain, James Skyes Gamble, Sir George Watt, Robert Pantling, George Gamie, William Wright Smith and G.H. Cave have contributed to the documentation of the biodiversity of the State. Significant contributions by Indian botanists have updated information on various taxonomic groups such as rhododendrons, orchids and ferns and other floral communities of the State by Pradhan and Lachungpa (1990), Sundriyal and Sharma (1996), Singh and Chauhan (1997), Lucksom (2007), Maiti and Maiti (2007), Tambe (2007), Pradhan and Badola (2008), Das (2009), Kholia (2010), Sharma and Sharma (2010), Arrawatia and Tambe (2011), Pradhan (2008), Kholia (2014).

Currently, a number of biodiversity surveys have been conducted by the JICA-assisted Sikkim Biodiversity Conservation and Forest Management Project (SBFP) for the inventory and monitoring of the vegetation of the state. Quantitative analysis and assessment of vegetation are necessary for evaluating and providing management strategies which are undertaken by various researchers of the state researchers (Pradhan

2013; Dahal 2015; Subba 2015; Pradhan 2015; Dahal 2016; Subba 2016; Dahal 2017; Sharma and Borthakur 2017; Subba *et al.* 2017; Subba *et al.* 2018).

Rapid Biodiversity Survey

Aims

Rapid Biodiversity Assessment approach is a tool developed by Conservation International for systematic biodiversity data collection and has been well accepted throughout the world. It is a medium of quickly collecting information on the floral and faunal species present in a given area and provides key information that can be used to manage and protect species of conservation concern and overall biodiversity.

The objective of the Rapid Biodiversity Survey (RBS) under the aegis of Sikkim Biodiversity Conservation and Forest Management Project (SBFP) is to further enhance the previous work on biodiversity studies in the state with a long-term perspective and bring the data so produced under the Geo-spatial platform. The RBS envisages assessing the biodiversity of different forest types of Sikkim by laying 1000 plots across the state.

Rapid Biodiversity Survey is being carried out in different protected areas, buffer zones and reserve forests of Sikkim with the aim:

- 1) To develop baseline information on key biological elements in forest, alpine, freshwater and agro ecosystems for monitoring and evaluation of the impacts of forest and biodiversity management,
- 2) To identify critical areas that requires immediate protection. As the forest and biodiversity information base synthesizes information from both the biophysical and social sciences, it should be accurate and complete.

Under this subcomponent, rapid biodiversity surveys, which would display the ecosystems throughout the state, are being conducted. The survey is carried out using both the coarse filter and fine filter approaches.

(a) Implementation of Rapid Biodiversity Survey (1,000 sample plots)

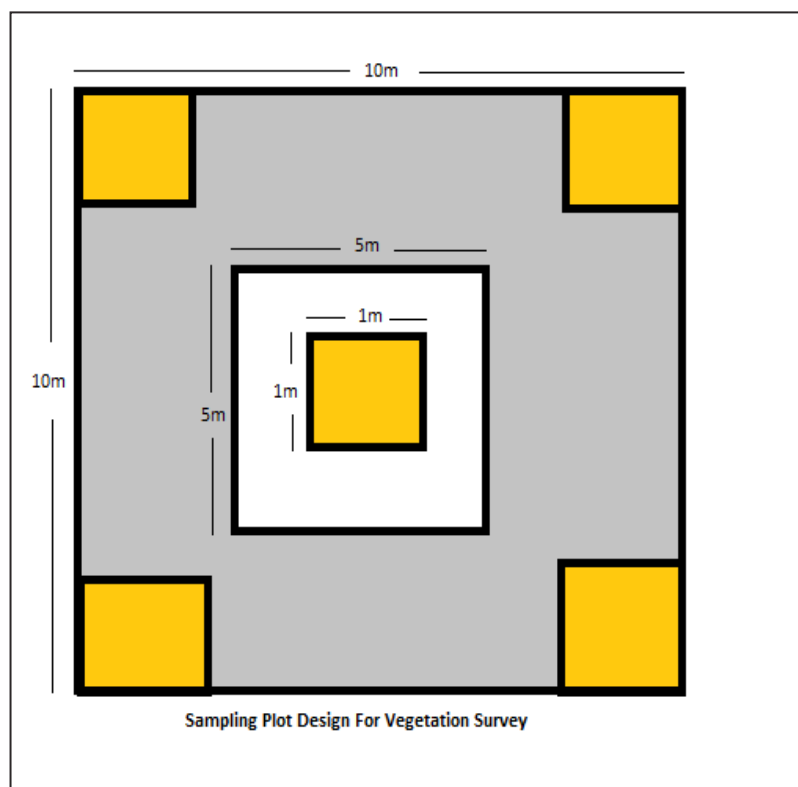
Approximately 1,000 sample plots are randomly generated throughout Sikkim for quantitative biodiversity study using the digital spatial information base (in case the randomly selected plots are snow covered area, such plots are not necessarily included).

(b) Detailed survey at Hotspots (300 sample plots)

In addition, known hotspots in forest, alpine, freshwater and agro-ecosystems will have approximately 300 more plots to present more detailed information. Enumeration and observation of all sample plots will be conducted.

Methodology

Inventory and monitoring of the biodiversity were done using Rapid Biodiversity Survey Techniques (RBST). Prior to field work, literatures were scrutinised to have a general idea about the biodiversity of the area (Polunin & Stainton 1984; Stainton 1988; Hooker 1871-1897; Sharma & Sharma 2010; Dahal 2015; Dahal 2016; Arrawatia & Tambe 2011; Lachungpa *et al.* 2007; Kholia 2010; Kohlia 2014; Das 2009) including web references such as (www.efloras.org; www.flowersofindia.net). The checklist of the species (both flora and fauna) was prepared and was taken to the field to confirm their presence in the study area. During the field work, general listing of all the species occurring in the area (both flora and fauna) were made to have fair knowledge on the biodiversity of the area.



In the field, quantitative as well as qualitative data on floral biodiversity was recorded using Standard Quadrat Sampling method, wherein, a random plot of 10m x 10m was established which was followed by laying sample plot after every 0.5 to 0.6 km approximate distance. Within the plot, all the tree species were listed and

individual trees with CBH >30 cm (1.37 m above the ground) was measured. Within the mother plot, a quadrat of 5m x 5m was laid in the centre to record the number of saplings present; the same quadrat was used to record the percent cover of the shrub species. Five quadrat of 1m x 1m were laid; 2 at the alternate corners of 5m x 5m quadrat and 1 at the centre for recording the percent cover of the herb species; the same quadrat was used to

record the number of seedlings. General listing of all the species (flora) encountered along the sampling plots as well as outside was also done to have fair idea on the species availability in the area. Parameters such as coordinates and altitude of each sample plots were recorded using hand held GPS; slope aspect and slope angle of each plots were also recorded.

Vegetation Data Analysis

For quantitative analysis of vegetation, recorded data were analyzed for density, frequency, abundance, basal area, importance value index and diversity using standard formulae.

1. Species diversity index (H)

Species diversity for each plot was determined with the Shannon and Wiener (1963) information function, which reads as:

$$H' = - \sum (n_i / N) \log_2 n_i / N$$

Where, 'n_i' represents the total number of individuals of particular species, and 'N' represents the total number of individuals of all species.

2. Species richness (I)

Species richness was calculated using Margalef's index of richness (1958) as:

$$I = (S-1) / \ln (N)$$

Where, 'S' is the number of species in the sample and 'N' is the total number of individuals in the sample.

3. Species evenness (E)

Species evenness was determined by using Shannon index of evenness as:

$$E = H / \ln (S)$$

Where, 'H' is Shannon Index of diversity and 'S' is the number of species in the sample.

4. Concentration of dominance (Cd)

Concentration of dominance was measured by Simpson's Index which reads as:

$$Cd = (n_i / N)^2$$

Where, 'n_i' represents the total number of individuals of particular species and 'N' represents the total number of individuals of all species.

5. Frequency (F)

Frequency indicates the number of times a particular species occurs at a given sampling unit. It is expressed in terms of percentage of occurrence and calculated as:

$$\text{Frequency (\%)} = \frac{\text{Total no. of quadrates in which species occurred} \times 100}{\text{Total no. of quadrates studied}}$$

6. Density (D)

Density was calculated as number of individuals per hectare:

$$\text{Density (D)} = \frac{\text{Total no. of individual in all the quadrates} \times 100}{\text{Total no. of quadrates studied}}$$

7. Abundance

$$\text{Abundance (A)} = \frac{\text{Total no. of individual of a species} \times 100}{\text{Total no. of quadrates in which the species occurred}}$$

8. Basal area

Basal area is one of the chief characters determining dominance of the community. It was computed using girth of the stems of trees at breast height (GBH) at 1.37m above ground level.

$$\text{Basal cover} = \text{Pi} * \text{r}^2$$

Where, "Pi" is a constant value = 3.14 and
"r" is the radius

9. Relative frequency (RF)

$$\text{RF} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

10. Relative density (RD)

$$\text{RD} = \frac{\text{No. of individual of a species}}{\text{Total no. of individual of all species}} \times 100$$

11. Relative dominance (RDo)

$$\text{RDo} = \frac{\text{Total basal cover of individual species} \times 100}{\text{Total basal cover of all species}}$$

12. Importance value index(IVI)

Importance value index is a measure of how dominant a species is in a given forest area. This index utilises three characteristics, viz. relative frequency, relative density and relative dominance. The three characteristics were computed using frequency, density and basal area for all species falling in all transects using following formulae:

$$\text{Importance value index (IVI)} = \text{Relative density (RD)} + \text{Relative frequency (RF)} + \text{Relative dominance (RDo)}$$

In case of shrubs and herbs, populations were calculated in terms of Average percent cover. Classification scheme of Forest Survey of India (FSI) were followed to analyse forest density on the basis of canopy cover which are defined herewith:

| | |
|--------------------------|--|
| Very Dense Forest | Canopy density of 70% and above |
| Mod Dense Forest | Canopy density between 40% and 70% |
| Open forest | Canopy density between 10% and 40% |
| Scrub | Forest land with poor tree growth, mainly small or stunted trees having canopy density less than 10% |

The book **Rapid Biodiversity Survey Report – V** is one of the series in RBS publication and is a sequel to Rapid Biodiversity Survey Report – I, II, III and IV. These reports are an attempt to assess the present phytosociological status of various Protected areas and Reserve forests of Sikkim.

Survey Outcomes

So far, RBS studies have been conducted in the following sampling paths of all the Protected Areas and 38 Reserve Forests of Sikkim.

1. Sang – Tinjurey sampling path in FambongLho Wildlife Sanctuary, East Sikkim
2. Yuksom – Dzungri – Goche La sampling path in Khangchengdzonga Biosphere Reserve, West Sikkim
3. Ravangla – Bhaley Dhunga sampling path in Maenam Wildlife Sanctuary, South Sikkim
4. Tholung – Kishong sampling path in Khangchengdzonga Biosphere Reserve, North Sikkim
5. Shingba Rhododendron Sanctuary – Yumthang Valley – Shiv Mandir in Lachung Range, North Sikkim
6. Kitam Bird Sanctuary, South Sikkim
7. Barsey Rhododendron Sanctuary, West Sikkim
8. Kyongnosla Alpine Sanctuary, East Sikkim

Apart from the above RBS study, inventorization of the floral species was also conducted in some of the locations as under:

1. Tendong State Biodiversity Park, Damthang, South Sikkim
2. Floriculture Nursery, Bulbuley, East Sikkim
3. Proposed Biodiversity Training Institute, Pangthang, East Sikkim
4. Proposed Butterfly Park, Rang Rang, North Sikkim
5. Gyam Tsona Lake, North Sikkim

FIELD ACTIVITIES



Survey team laying 10m x 10m sampling plot



Survey team measuring girth of a tree



Survey team enumerating species



Eria coronaria



Dendrobium ochreatum

Rapid Biodiversity Survey of Assam Reserve Forest, East Sikkim

Sabita Dahal, Meena Tamang, Suraj Subba



Photo 1: Ashy Drongo

STUDY AREA

A field trip for conducting Rapid Biodiversity Survey to Assam Reserve Forest covering a sampling path from Latape Dara – Below Menla – Thekabong in East Sikkim was carried out during the month of October 2017 by the SBFP survey team. The trip was aimed at inventorizing and monitoring of the biodiversity of the area.

The present survey area encompasses Latape Dara – below Menla – Thekabong sampling path, the forest type of which is represented by sub-tropical to subalpine forest. The elevation range covered during the survey was from 1700m (Latape Dara, above Assam Lingzey) to 3200m (below Menla) which is represented in **Figure 1a, 1b, 1c**. The slope angle of the area ranged between mild (30 degree) to steep (80 degree) slope and is facing towards E, NE and SE aspect as shown in **Table 1**.

Forest being subtropical to temperate type, trees are the most predominant taxa in the area, followed by herbs, shrubs and shrublets, ferns, climbers and epiphytes. The area constitutes a diverse habitat for both flora and fauna of the subtropical to subalpine belt. The area is highly dominated with trees and small tree species namely *Symplocos theifolia* Don., *Machilus edulis*, *Elaeocarpus lanceifolius*, *Lithocarpus fenestrata* Roxb., *Castanopsis tribuloides* (Smith) A. DC., *Castanopsis hystrix* Hook. & Thomson ex. A. DC., *Brassaiopsis mitis* C.B.Clarke, *Quercus pachyphylla* Kurz., *Pyrularia edulis* (Wallich) A., *Pieris ovalifolia* D. Don, *Michelia cathcartii* Hook. f. Thomson, *Maesa chisia* Buch.-Ham. ex D. Don, *Machilus gammieana* King ex. Hook. f., *Antidesma acuminatum* Wight, *Acer caudatum* Wallich, *Rhododendron grande* Wright, *Rhododendron falconeri* Hook.f., etc. Common shrub species of the area are *Rubus ellipticus* Smith., *Rubus niveus* Thunb., *Rubus paniculatus* (Smith) Rees., *Viburnum erubescens* Wallich ex DC., *Dichroa febrifuga* Lour, *Maesa chisia* Don, *Oxyropa paniculata* (D.Don) DC, *Polygala arillata* Buch.- Ham ex D.Don, etc.



Photo 2: *Amomum dealbatum* (Churumpha) habitat (left), fruit (right)

Forest harbors common mammals such as Jackel, Squirrel, Goral, Himalayan palm civet, Wild pig; avi-faunal species such as Common pigeon, Common myna, Great barbet, Himalayan bulbul, House crow, House sparrow, Kalij pheasant, Large-billed crow, Oriental turtle dove, Oriental white-eyed ash drongo, Verditer flycatcher, Red-tailed minla, etc.

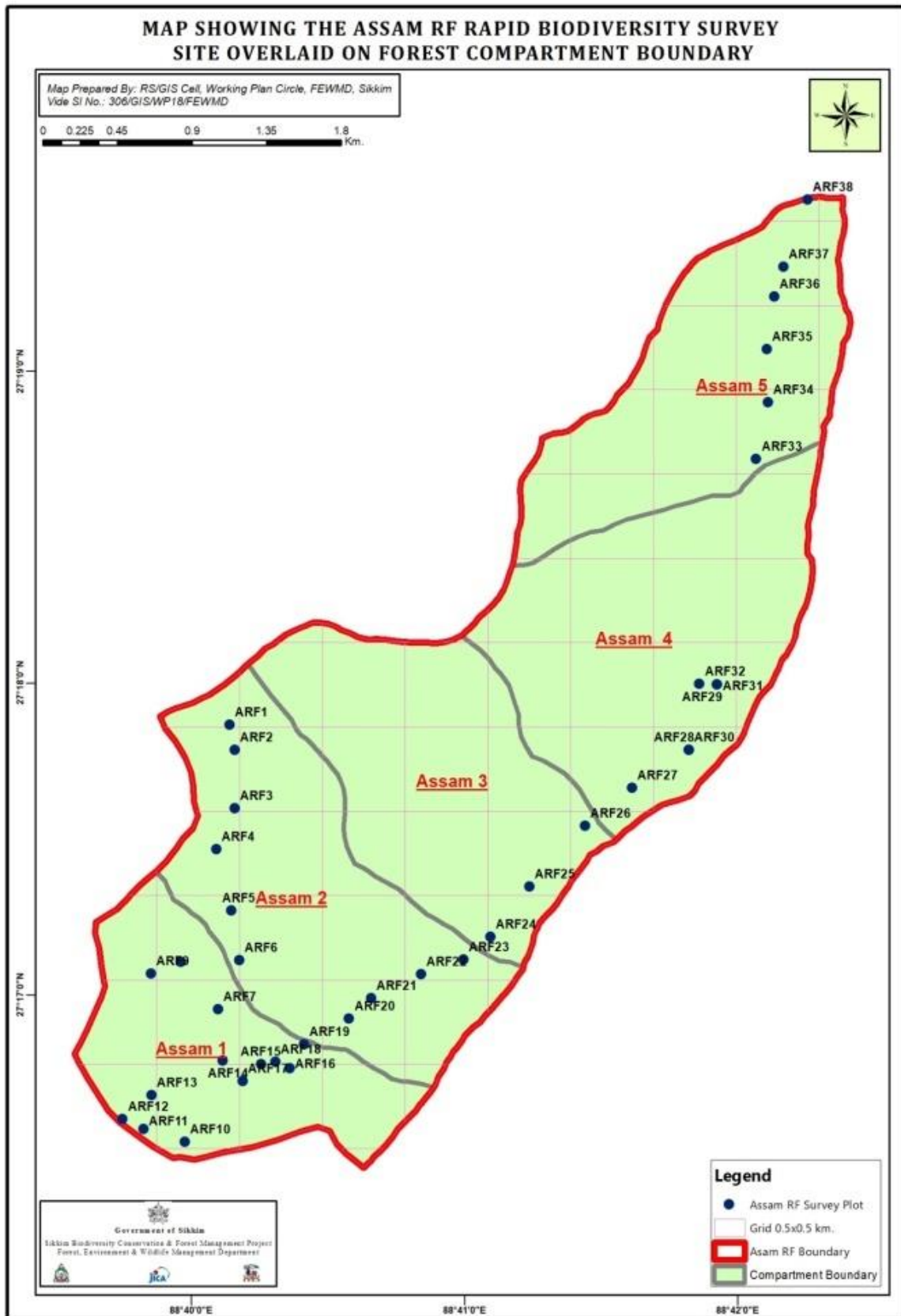


Figure 1a: Rapid biodiversity survey plots along Latape Dara – Below Menla – Thekabong sampling path showing forest compartment

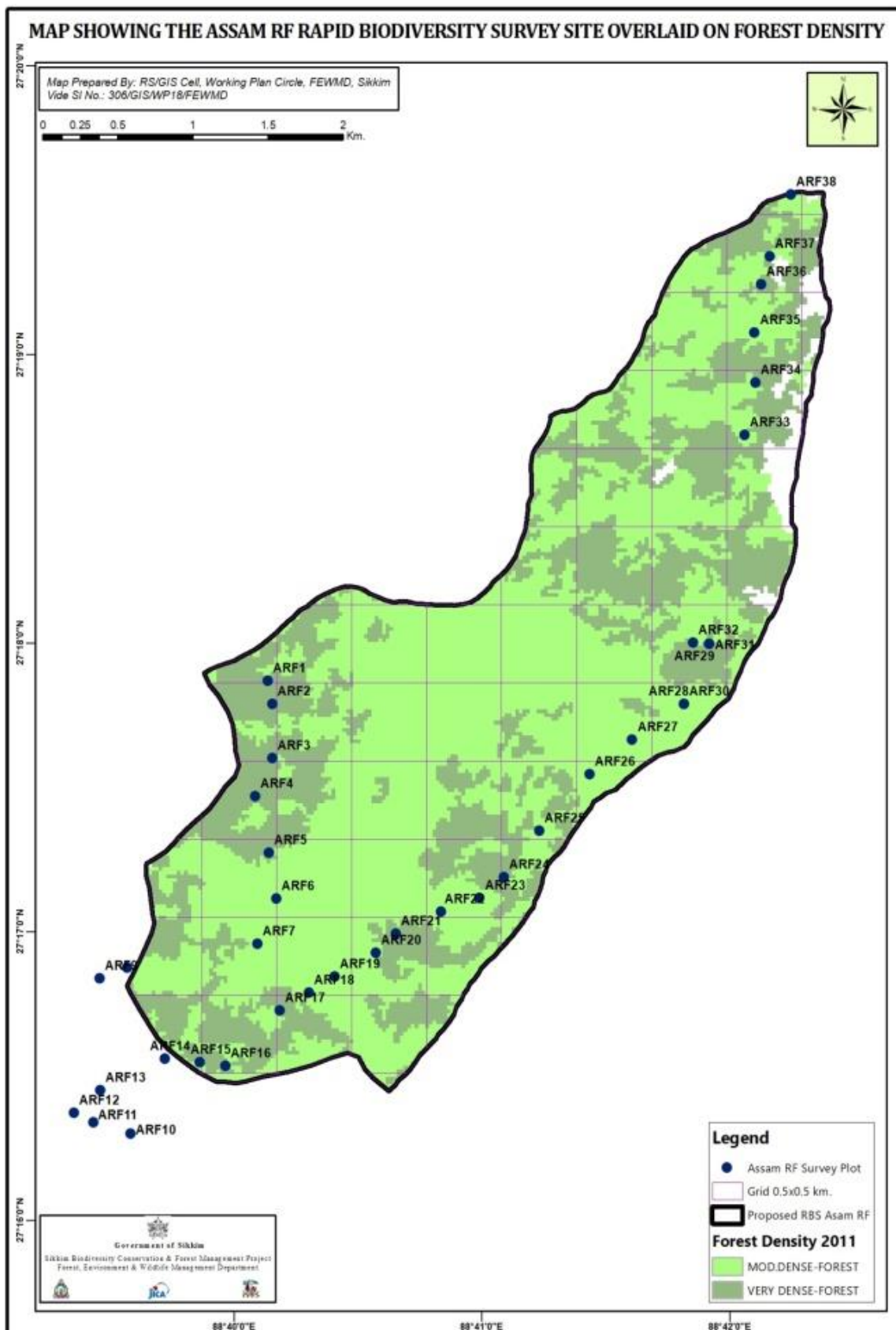


Figure 1b: Rapid biodiversity survey plots along Latape Dara – Below Menla – Thekabong sampling path showing forest density

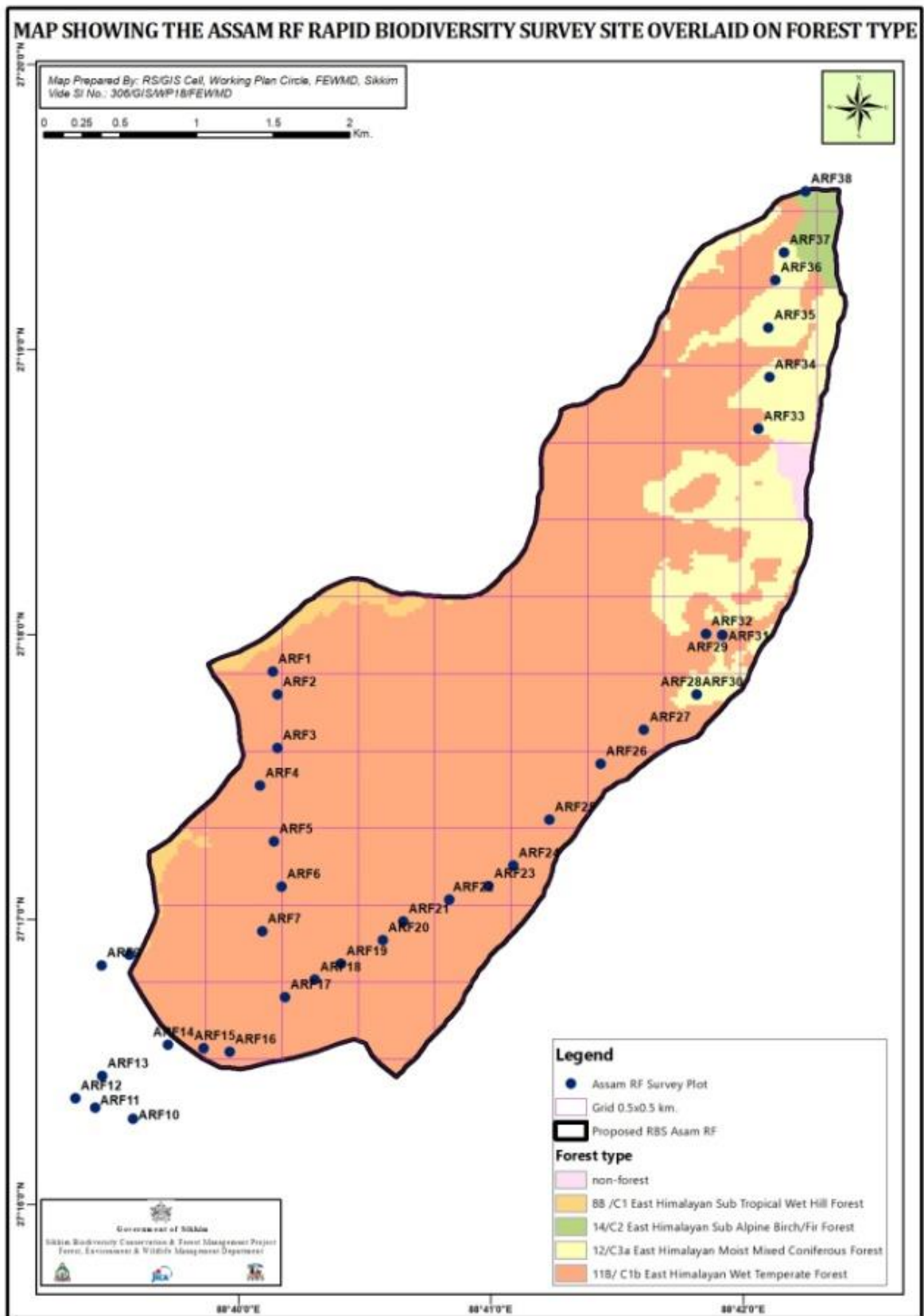


Figure 1c: Rapid biodiversity survey plots along Latape Dara – Below Menla–Thekabong sampling path showing forest type

Table I: Site characteristics of the survey area along Latape Dara – Below Menla – Thekabong sampling path in Assam RF, East Sikkim

| Site Code | Forest type | Elevation (M) | GPS co-ordinates | | Slope angle (°) | Slope aspect | Canopy cover / Forest Density | Dominant taxa | Disturbances | Location |
|-----------|---------------|---------------|------------------|-------------|-----------------|--------------|-------------------------------|---------------|--------------|-----------------|
| | | | Latitude | Longitude | | | | | | |
| ARF1 | Wet Temperate | 1774 | 27°17'10.6" | 88°39'33.0" | 55 | E | 95%, Very dense | Trees | Nil | Latape Dara |
| ARF2 | Wet Temperate | 1749 | 27°17'05.8" | 88°39'34.1" | 30 | E | 10%, Open | Herbs | Grazing | Parengtar |
| ARF3 | Wet Temperate | 1788 | 27°16'54.5" | 88°39'33.9" | 45 | E | 65%, Moderately dense | Tree | Grazing | |
| ARF4 | Wet Temperate | 1789 | 27°16'46.7" | 88°39'29.7" | 30 | E | 50%, Moderately dense | Tree | Nil | |
| ARF5 | Wet Temperate | 1859 | 27°16'34.8" | 88°39'32.8" | 40 | E | 50%, Moderately dense | Tree | Nil | Ghopy Kharika |
| ARF6 | Wet Temperate | 1911 | 27°16'25.3" | 88°39'34.5" | 55 | E | 55%, Moderately dense | Tree | Grazing | (Above Goth) |
| ARF7 | Wet Temperate | 1974 | 27°16'15.9" | 88°39'29.7" | 45 | NE | 60%, Moderately dense | Tree | - | Thonuki Goth |
| ARF8 | Wet Temperate | 1840 | 27°16'11.4" | 88°38'58.1" | 75 | NE | 60%, Moderately dense | Tree | Nil | Beteni |
| ARF9 | Wet Temperate | 1838 | 27°16'09.2" | 88°38'51.4" | 60 | NE | 85%, Very dense | Tree | | |
| ARF10 | Wet Temperate | 1782 | 27°15'36.8" | 88°38'58.4" | 75 | NE | 80%, Very dense | Tree | Nil | Thekabong |
| ARF11 | Wet Temperate | 1867 | 27°15'39.3" | 88°38'49.4" | 30 | NE | 50%, Moderately dense | Tree | Nil | Thekabong |
| ARF12 | Wet Temperate | 1899 | 27°15'41.3" | 88°38'44.8" | 30 | NE | 40%, Moderately dense | Tree | Nil | Below Deorali |
| ARF13 | Wet Temperate | 1920 | 27°15'45.9" | 88°38'51.2" | 30 | NE | 70%, Very dense | Tree | Nil | Deorali |
| ARF14 | Wet Temperate | 1994 | 27°15'52.3" | 88°39'07.0" | 30 | E | 50%, Moderately dense | Tree | Nil | Dhajay |
| ARF15 | Wet Temperate | 2083 | 27°15'51.5" | 88°39'15.4" | 45 | E | 85%, Very dense | Tree | Nil | |
| ARF16 | Wet Temperate | 2093 | 27°15'50.7" | 88°39'21.6" | 60 | E | 60%, Moderately dense | Tree | Nil | Honey Dara |
| ARF17 | Wet Temperate | 2172 | 27°16'02.0" | 88°39'34.9" | 60 | E | 50%, Moderately dense | Tree | Nil | |
| ARF18 | Wet Temperate | 2216 | 27°16'05.6" | 88°39'42.1" | 60 | E | 75%, Moderately dense | Tree | Nil | |
| ARF19 | Wet Temperate | 2283 | 27°16'08.9" | 88°39'48.4" | 70 | E | 75%, Very dense | Tree | Nil | Below Gorujuray |
| ARF20 | Wet Temperate | 2368 | 27°16'13.7" | 88°39'58.4" | 70 | E | 80%, Very dense | Tree | Nil | |

| | | | | | | | | | | |
|-------|---------------|------|-------------|-------------|----|----|-----------------------|---------------|---------|---------------------|
| ARF21 | Wet Temperate | 2423 | 27°16'17.6" | 88°40'03.3" | 70 | E | 90%, Very dense | Tree | Nil | |
| ARF22 | Wet Temperate | 2490 | 27°16'22.1" | 88°40'14.3" | 70 | E | 90%, Very dense | Tree | Nil | |
| ARF23 | Wet Temperate | 2566 | 27°16'24.8" | 88°40'23.7" | 80 | E | 85%, Very dense | Tree | Nil | Below Khedi |
| ARF24 | Wet Temperate | 2593 | 27°17'09.9" | 88°41'06.7" | 80 | E | 85%, Very dense | Tree | Nil | |
| ARF25 | Wet Temperate | 2600 | 27°17'19.5" | 88°41'15.4" | 80 | E | 90%, Very dense | Tree | Nil | |
| ARF26 | Wet Temperate | 2649 | 27°17'31.1" | 88°41'27.8" | 60 | E | 80%, Very dense | Tree | Nil | Below Khedi |
| ARF27 | Wet Temperate | 2649 | 27°17'38.2" | 88°41'38.2" | 30 | E | 90%, Very dense | Tree | Nil | Khedi area |
| ARF28 | Wet Temperate | 2645 | 27°17'45.4" | 88°41'50.8" | 35 | E | 90%, Very dense | Tree | Grazing | Khedi |
| ARF29 | Wet Temperate | 2638 | 27°17'57.9" | 88°41'57.2" | 30 | E | 80%, Very dense | Tree | Grazing | Khedi |
| ARF30 | Wet Temperate | 2645 | 27°17'45.4" | 88°41'50.8" | 30 | E | 80%, Very dense | Tree | Grazing | Khedi |
| ARF31 | Wet Temperate | 2638 | 27°17'57.9" | 88°41'57.2" | 40 | SE | 75%, Very dense | Tree | Grazing | Above Khedi Pokhari |
| ARF32 | Wet Temperate | 2627 | 27°17'58.1" | 88°41'53.3" | 30 | SE | 50%, Moderately dense | Tree | Grazing | Above Khedi Pokhari |
| ARF33 | Wet Temperate | 2880 | 27°18'48.0" | 88°42'09.7" | 50 | SE | 80%, Very dense | Tree & Bamboo | Grazing | Above Khedi |
| ARF34 | Wet Temperate | 2959 | 27°18'58.9" | 88°42'12.5" | 55 | SE | 30%, Open | Tree & Bamboo | Grazing | Above Khedi |
| ARF35 | Wet Temperate | 3001 | 27°19'09.2" | 88°42'12.4" | 60 | SE | 30%, Open | Tree & Bamboo | Grazing | Above Khedi |
| ARF36 | Wet Temperate | 3066 | 27°19'19.2" | 88°42'14.2" | 50 | SE | 30%, Open | Tree & Bamboo | Grazing | Above Khedi |
| ARF37 | Wet Temperate | 3108 | 27°19'25.0" | 88°42'16.3" | 45 | SE | 45%, Moderately dense | Rhododendrons | Nil | Above Khedi |
| ARF38 | Wet Temperate | 3170 | 27°19'37.8" | 88°42'21.7" | 50 | SE | 40%, Moderately dense | Shrubs | Nil | Below Menla |

FINDINGS

Flora

During the survey in Assam Reserve Forest, a total of 38 sample plots were laid covering an area of 0.38 ha (**Table 1; Figure 1a, b, c**) from which 50 species of trees and small trees, 4 species of bamboos, 14 species of shrubs, 47 species of herbs (including ferns) were recorded and are marked with (*) in **Annexure 1**. A general checklist of the floral species of the area (including the areas outside the plots) were prepared of which, trees and small trees represented the highest number of species (67 species) followed by herbs (61 species), 29 species of climbers and epiphytes, 24 species of shrubs and shrublets, 26 number of ferns and fern allies, 10 species of bamboos and cane were recorded from the area during the present study (**Table 2**). Plot-wise location name, dominant taxa, elevation, GPS-coordinates, forest type, slope angle, slope aspect, disturbances and forest density of the area in terms of canopy cover in and around the sample plots are provided in **Table 1**. Family-wise analysis of

tree/small tree species revealed that Lauraceae and Fagaceae was the dominant species with 8 and 7 species, respectively

| Habit | Species | Genus | Family |
|--------------------------------------|------------|-------|--------|
| Trees and Small trees / large shrubs | 67 | 51 | 33 |
| Shrubs / shrublets | 24 | 15 | 10 |
| Herbs | 61 | 45 | 28 |
| Epiphytes / Climbers | 29 | 24 | 21 |
| Ferns / Fern allies | 26 | 21 | 15 |
| Bamboo and Cane | 10 | 9 | 3 |
| Total | 217 | 165 | 110 |

(**Figure 2**). In case of ground vegetation (shrubs and herbs including climbers, creepers, ferns, bamboos), Urticaceae and Poaceae are the dominant species followed by Polypodiaceae, Rosaceae, Pteridaceae, Woodsiaceae, Asteraceae (**Figure 3**).

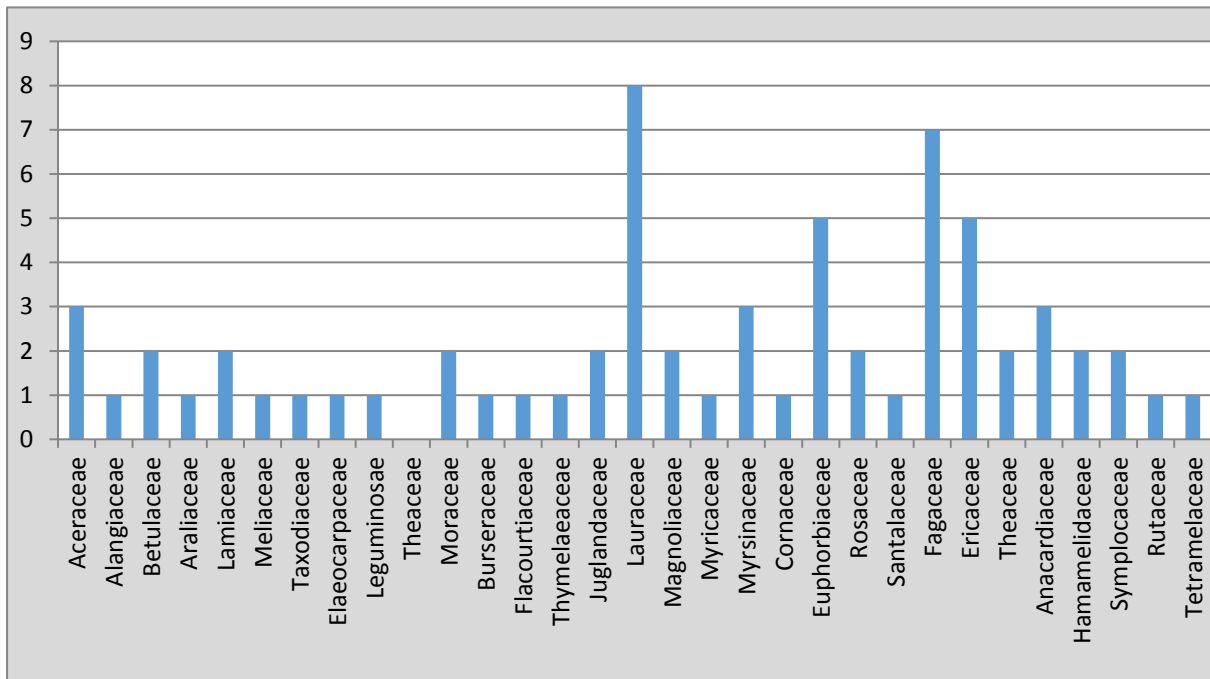


Figure 2: Family-wise distribution of tree species

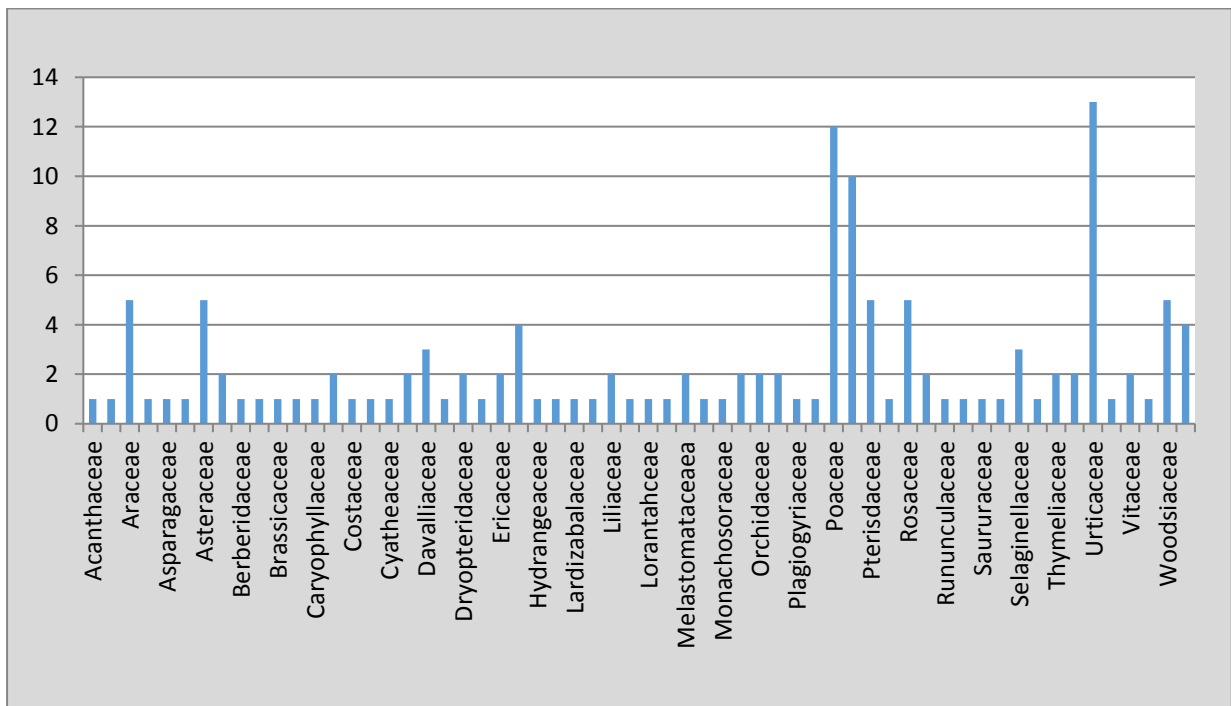


Figure 3: Family-wise distribution of ground vegetation including small shrubs, herbs, climbers, creepers and ferns

POPULATION FIGURE OF THE FLORAL SPECIES IN ASSAM RESERVE FOREST

Trees / Small Trees / Large Shrubs

In the lower belt of the forest, *Macaranga postulata*, *Symplocos theifolia*, *Machilus edulis*, *Quercus lamellosa*, *Castanopsis indica*, *Elaeocarpus lanceifolius*, *Viburnum erubescens* were the dominant species in the lower belt with the highest cumulative adult stem density and total basal cover whereas *Rhododendron falconeri* was the dominant tree in the upper belt (**Table 3**). However, some species have been recorded with very less number of populations such as that of *Acer campbellii*, *Beilschmiedia sikkimensis*, *Cinnamomum obtusifolium*, *Exbucklandia populnea*, *Hovenia dulcis*, *Juglans regia*. Along the upper region of the forest, *Yushania maling* appeared as highly dominating species. *Yushania maling* is a bamboo species; however, the species cannot be ignored while conducting population estimation because it is the highly dominating species in the upper belt of temperate forest. For the species of bamboo, the number of clumps was counted to analyze population in terms of individual plant density per hectare. The availability and distribution of the tree species including saplings and seedlings in the area in terms of density, total basal cover (TBC), abundance – frequency ratio (A/F ratio), important value index (IVI) are represented in **Table 3**.

The availability and distribution of trees species in terms of Diversity Index (H), Concentration of Dominance (D), Species Richness Index (I) and Species Evenness Index (E) are represented in **Table 4** and **Figure 4**.



Photo 3: *Elaeocarpus lanceaeifolius* fruits (left), seeds (Right)

| Table 3: Availability and distribution of tree and bamboo species (highly dominating taxa) in Assam RF, East Sikkim | | | | | | | | | | |
|---|------------------------------|------------------|-----------------|--------------------------|-----------|-------|------------------|------------------|------------------|------------------|
| Species | Adult | | | | | | Saplings | | Seedlings | |
| | Trees / Small trees/ Bamboos | Density (ind/ha) | SE (density)/ha | TBC (m ² /ha) | A/F Ratio | IVI | Density (ind/ha) | Density (ind/ha) | Density (ind/ha) | Density (ind/ha) |
| <i>Acer campbellii</i> | | 7.895 | 15.78 | 95.981 | 0.127 | 3.34 | 10.53 | | | |
| <i>Acer caudatum</i> | | 18.421 | 37.62 | 208.148 | 0.296 | 25.58 | - | | | 21.05 |
| <i>Acer pectinatum</i> | | 21.053 | 25.80 | 320.239 | 0.122 | 7.78 | - | | | 13.16 |
| <i>Alangium begoniaefolium</i> | | 5.263 | 16.00 | 5.200 | 0.190 | 1.76 | - | | | - |
| <i>Beilschmiedia sikkimensis</i> | | 2.632 | 16.22 | - | 0.380 | 0.91 | - | | | - |
| <i>Betula alnoides</i> | | 7.895 | 25.37 | 110.679 | 0.285 | 11.40 | - | | | - |
| <i>Brassaiopsis mitis</i> | | 10.526 | 15.55 | - | 0.095 | 3.66 | 7.89 | | | - |
| <i>Callicarpa arborea</i> | | 10.526 | 35.98 | 19.091 | 0.380 | 3.10 | - | | | - |
| <i>Castanopsis indica</i> | | 26.316 | 93.99 | 1815.789 | 0.950 | 27.58 | - | | | - |
| <i>Castanopsis tribuloides</i> | | 18.421 | 20.99 | 600.077 | 0.009 | 18.26 | - | | | - |
| <i>Castanopsis hystrix</i> | | 10.526 | 64.89 | 759.904 | 1.520 | 11.97 | - | | | - |
| <i>Cinnamomum obtusifolium</i> | | 2.632 | 16.22 | | 0.380 | 6.55 | - | | | - |
| <i>Cryptomeria japonica</i> | | 2.632 | 16.22 | | 0.380 | 3.44 | - | | | - |
| <i>Elaeocarpus lanceifolius</i> | | 21.053 | 40.80 | 608.154 | 0.760 | 9.05 | 7.89 | | | - |
| <i>Engelhardtia spicata</i> | | 5.263 | 32.44 | 491.116 | 0.760 | 8.71 | - | | | - |
| <i>Erythrina arborescens</i> | | 2.632 | 16.22 | 6.570 | 0.380 | 1.08 | - | | | - |
| <i>Eurya acuminata</i> | | 21.053 | 33.20 | 58.636 | 0.190 | 5.63 | 7.89 | | | 36.84 |
| <i>Exbucklandia populnea</i> | | 5.263 | 16.00 | 15.137 | 0.190 | 2.24 | - | | | - |
| <i>Ficus nemoralis</i> | | 5.263 | 16.00 | 3.899 | 0.190 | 2.17 | - | | | - |
| <i>Garuga pinnata</i> | | 23.684 | 49.20 | 117.559 | 0.380 | 5.88 | - | | | - |
| <i>Hovenia dulcis</i> | | 5.263 | 16.00 | 57.880 | 0.190 | 2.86 | - | | | - |
| <i>Juglans regia</i> | | 5.263 | 32.44 | 75.636 | 0.760 | 6.56 | - | | | - |
| <i>Lyonia ovalifolia</i> | | 10.526 | 50.88 | - | 1.520 | 8.27 | - | | | - |
| <i>Macaranga pustulata</i> | | 52.632 | 35.29 | 10.746 | 0.094 | 59.84 | - | | | - |
| <i>Machilus edulis</i> | | 36.842 | 51.38 | 252.348 | 0.213 | 10.98 | - | | | 21.05 |

| | | | | | | | |
|------------------------------------|---------|--------|----------|-------|-------|-------|-------|
| <i>Machilus gamblei</i> | 15.789 | 48.00 | 221.844 | 0.570 | 5.09 | - | - |
| <i>Magnolia cathcartii</i> | 26.316 | 27.97 | 501.372 | 0.106 | 30.64 | - | - |
| <i>Magnolia doltsopa</i> | 15.789 | 39.20 | 79.257 | 0.253 | 5.53 | - | - |
| <i>Nyssa sessiliflora</i> | 10.526 | 22.42 | 226.334 | 0.169 | 6.38 | - | - |
| <i>Prunus nepalensis</i> | 7.895 | 25.37 | 16.120 | 0.285 | 8.90 | - | - |
| <i>Pyralia edulis</i> | 2.632 | 16.22 | - | 0.380 | 0.91 | - | - |
| <i>Quercus lamellosa</i> | 55.263 | 24.72 | 1754.056 | 0.047 | 20.62 | - | - |
| <i>Quercus pachyphylla</i> | 2.632 | 16.22 | 121.371 | 0.380 | 9.24 | - | - |
| <i>Rhododendron arboreum</i> | 7.895 | 15.78 | 215.173 | 0.127 | 3.34 | - | - |
| <i>Rhododendron barbatum</i> | 10.526 | 15.55 | 20.396 | 0.095 | 3.66 | - | - |
| <i>Rhododendron falconeri</i> | 102.632 | 68.77 | 678.744 | 0.148 | 31.59 | - | 50.00 |
| <i>Rhododendron grande</i> | 55.263 | 94.94 | 331.849 | 0.499 | 16.77 | - | 13.16 |
| <i>Rhus succedanea</i> | 5.263 | 32.44 | 52.742 | 0.760 | 7.27 | - | - |
| <i>Symplocos theifolia</i> | 71.053 | 55.29 | - | 0.127 | 27.53 | 47.37 | - |
| <i>Symplocos glomerata</i> | 5.263 | 16.00 | 6.388 | 0.190 | 4.41 | - | 65.79 |
| <i>Tetradium fraxinifolium</i> | 5.263 | 32.88 | 18.909 | 0.760 | 5.75 | 5.26 | - |
| <i>Viburnum erubescens</i> | 31.579 | 34.36 | 164.396 | 0.127 | 26.38 | 13.16 | 28.95 |
| <i>Wrightia gigantea</i> | 5.263 | 32.44 | 3.059 | 0.760 | 9.56 | - | - |
| <i>Zanthoxylum acanthopodium</i> | 5.263 | 32.44 | 12.883 | 0.760 | 9.98 | - | 13.16 |
| Unidentified | 18.421 | 20.99 | 34.047 | 0.009 | 18.26 | - | - |
| Bamboo species | | | | | | | |
| <i>Daphnophyllum himalayense</i> | 21.053 | 25.80 | - | 0.122 | 7.78 | - | - |
| <i>Drepanostachyum intermedium</i> | 31.579 | 97.41 | - | 1.140 | 4.36 | - | - |
| <i>Himalayacalamus hookerianus</i> | 15.789 | 34.29 | - | 0.253 | 4.24 | - | - |
| <i>Themnocalamus falconeri</i> | 31.579 | 88.13 | - | 0.507 | 5.72 | - | - |
| <i>Yushania maling</i> | 247.368 | 232.95 | - | 0.729 | 58.13 | - | - |

| Table 4: Species diversity and distribution in Assam RF, East Sikkim | | | |
|--|--------|----------|-----------|
| Parameters | Trees | Saplings | Seedlings |
| Diversity Index (H) | 3.352 | 2.41 | 2.44 |
| Concentration of Dominance (D) | 0.023 | - | - |
| Species Richness Index (I) | 53.835 | 13.764 | 13.80 |
| Species Evenness Index (E) | 0.840 | 0.567 | 0.489 |

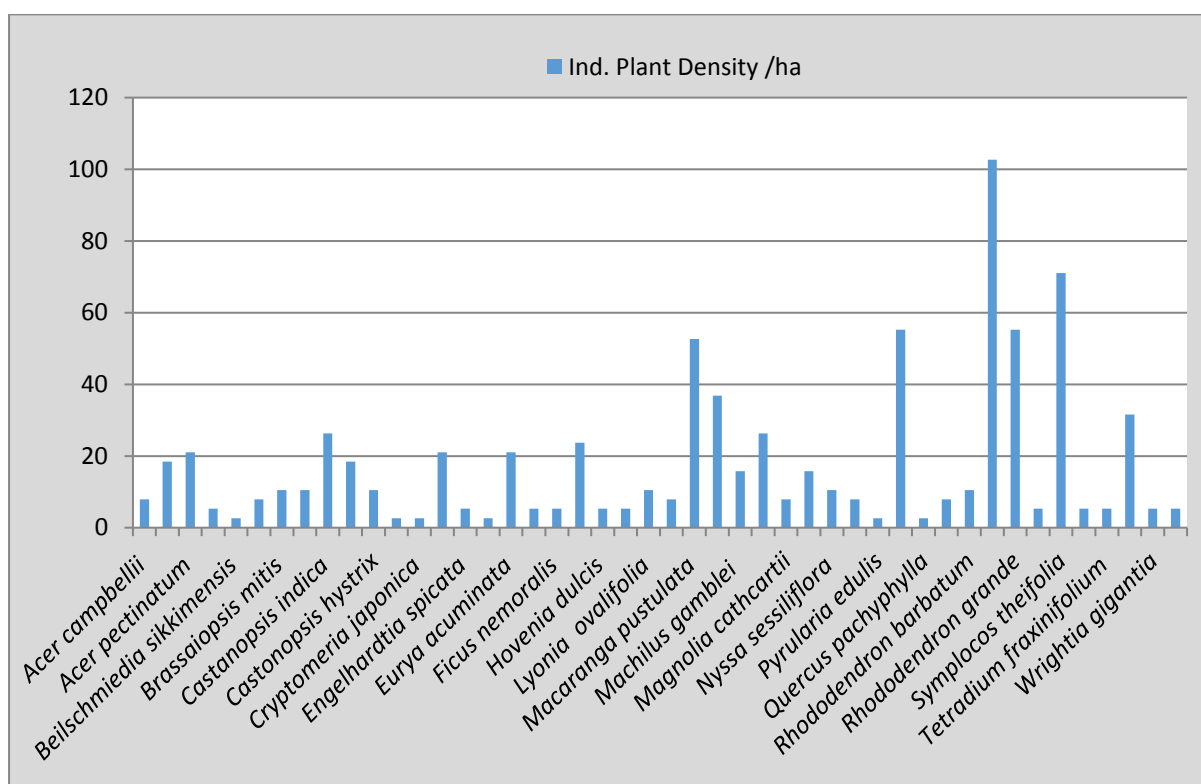


Figure 4: Availability and distribution of trees in Assam RF, East Sikkim

Ground Flora

The shrubs and shrublets recorded from the sample plots are *Viburnum erubescens*, *Maesa chisia*, *Edgeworthia gardenerii*, *Dichroa febrifuga*, *Osbeckia stellata*, *Daphne papyracea*, *Rubus* sp., *Rubus ellipticus*, *Antidesma acuminatum*, *Leucosceptrum cannum*, *Massaenda ruxburghii*, *Eurya acuminata*, *Symplocos theifolia*, *Daphne papyraceae*, *Polygala arillata*, *Rhododendron barbatum* and *Gaultheria nummularioides*. The availability and distribution of shrubs and shrublets in terms of average percent cover and percent

Table 5: Availability and distribution of shrubs and shrublets in Assam RF, East Sikkim

| | Species | Local name | % Frequency | % Cover |
|-----|---------------------------------|---------------|-------------|---------|
| 1. | <i>Viburnum erubescens</i> | Asaray | 2.18 | 18.42 |
| 2. | <i>Maesa chisia</i> | Bilauney | 1.32 | 5.26 |
| 3. | <i>Edgeworthia gardenerii</i> | Argali | 0.26 | 2.63 |
| 4. | <i>Dichroa febrifuga</i> | Basak | 1.32 | 10.53 |
| 5. | <i>Osbeckia stellata</i> | Osbeckia | 0.66 | 2.63 |
| 6. | <i>Antidesma acuminatum</i> | Lek Bilauney | 0.66 | 10.53 |
| 7. | <i>Leucosceptum cannum</i> | Ghurpis lekh | 0.18 | 5.26 |
| 8. | <i>Massaenda ruxbughii</i> | Dhubinee phul | 0.79 | 2.63 |
| 9. | <i>Eurya acuminata</i> | Jhigunay | 0.13 | 2.63 |
| 10. | <i>Symplocos theifolia</i> | Kharanay | 0.55 | 10.53 |
| 11. | <i>Daphne papyraceae</i> | Kalo argelee | 0.39 | 5.26 |
| 12. | <i>Polygala arillata</i> | Marcha jhar | 0.79 | 2.63 |
| 13. | <i>Gaultheria nummeroloides</i> | Dhasingray | 0.79 | 5.26 |
| 14. | <i>Rhododendron barbatum</i> | Lal chimal | 1.18 | 5.26 |

frequency are represented in **Table 5**. Likewise, the availability and distribution of bamboo / cane and herbs species are represented in **Tables 5** and **6**, respectively. Diversity of the ground covering herb species in the area was recorded high, but in terms of density, percent cover and percent frequency, the values were comparatively less in the area, which may be because of the high canopy cover inside the forest.

Table 6: Availability and distribution of bamboo and cane species in Assam RF, East Sikkim

| | Botanical name | Local name | % Frequency | % Cover |
|----|------------------------------------|----------------|-------------|---------|
| 1. | <i>Drepanostachyum intermedium</i> | Nigalo | 5.26 | 2.11 |
| 2. | <i>Himalayacalamus falconeri</i> | Singanay bans | 5.26 | 0.92 |
| 3. | <i>Himalayacalamus hookerianus</i> | Paryang | 2.63 | 0.26 |
| 4. | <i>Plectocomia himalayana</i> | Beth (Fyakray) | 2.63 | 0.26 |
| 5. | <i>Yushania maling</i> | Malingo | 18.42 | 7.63 |

| Table 7: Availability and distribution of herbs species in Assam RF, East Sikkim | | | | |
|--|-----------------------------------|--------------------|-------------|---------|
| Sl. No | Botanical name | Local name | % Frequency | % Cover |
| 1 | <i>Aconogonum campanulatum</i> | Kukurthotnay | 13.16 | 0.92 |
| 2 | <i>Aconogonum molle</i> | Thotnay | 10.53 | 1.18 |
| 3 | <i>Acorus calamus</i> | Bojo | 2.63 | 1.05 |
| 4 | <i>Aeschynanthus hookeri</i> | Baklaypatay | 10.53 | 1 |
| 5 | <i>Aeschynanthus parviflorus</i> | Baklaypatay | 10.53 | 0.61 |
| 6 | <i>Ampelocissus latifolia</i> | Pani lahara | 2.63 | 0.39 |
| 7 | <i>Anaphalis triplinervis</i> | BukeyPhool | 7.89 | 0.79 |
| 8 | <i>Arisaema flavum</i> | Sap ko makai | 2.63 | 0.13 |
| 9 | <i>Arisaema intermedium</i> | Larua/Banko | 2.63 | 0.26 |
| 10 | <i>Arisaema speciosum</i> | Sap ko Makai | 2.63 | 0.13 |
| 11 | <i>Artemisia vulgaris</i> | Titaypati | 7.89 | 0.34 |
| 12 | <i>Asplenium laciniatum</i> | Uniu | 2.63 | 0.26 |
| 13 | <i>Begonia picta</i> | Magar kanje | 7.89 | 1.05 |
| 14 | <i>Blechnum orientale</i> | Deer Fern | 2.63 | 0.53 |
| 15 | <i>Boehmaria platyphylla</i> | Kamley | 5.26 | 0.21 |
| 16 | <i>Campylandra aurantiaca</i> | Jangali nakima | 5.26 | 1.32 |
| 17 | <i>Carex</i> sp. | Harkatto | 7.89 | 0.61 |
| 18 | <i>Cautleya spicata</i> | Sara | 7.89 | 0.53 |
| 19 | <i>Coelogyne flaccida</i> | Sunakhari | 10.53 | 0.66 |
| 20 | <i>Commelina benghalensis</i> | Kanay | 2.63 | 0.26 |
| 21 | <i>Coniogramme intermedia</i> | Uniu | 2.63 | 0.26 |
| 22 | <i>Cyanotis vaga</i> | Kanay | 5.26 | 0.26 |
| 23 | <i>Cyathea spinulosa</i> | Rukh uniu | 2.63 | 0.26 |
| 24 | <i>Cynodon dactylon</i> | Dubo | 5.26 | 1.32 |
| 25 | <i>Dendrobium densiflorum</i> | Ghogay sunakhari | 2.63 | 0.26 |
| 26 | <i>Dennstaedtia appendiculata</i> | Pirey uniu | 10.53 | 0.79 |
| 27 | <i>Digitaria ciliaris</i> | Chitray banso | 5.26 | 0.26 |
| 28 | <i>Digitaria sanguinalis</i> | Banso | 5.26 | 0.53 |
| 29 | <i>Diplazium dilatatum</i> | Lek Chipley Ningro | 5.26 | 0.53 |
| 30 | <i>Diplazium esculentum</i> | Chiplay ningro | 5.26 | 0.26 |
| 31 | <i>Diplazium stoliczkae</i> | Lek Kalo Ningro | 5.26 | 0.39 |
| 32 | <i>Elatostema platyphyllum</i> | Gagleto | 5.26 | 0.26 |
| 33 | <i>Elatostema sessile</i> | Gagleto | 5.26 | 0.26 |
| 34 | <i>Equisetum diffusum</i> | Sallibisalli | 7.89 | 0.53 |
| 35 | <i>Eupatorium adenophorum</i> | Kali jhar | 7.89 | 0.81 |
| 36 | <i>Fragaria nubicola</i> | Bhui-aiselu | 5.26 | 0.26 |

| | | | | |
|----|----------------------------------|-------------------------------|-------|------|
| 37 | <i>Gerardiana diversifolia</i> | Bhang resisnu | 7.89 | 0.69 |
| 38 | <i>Gleichenia gigantean</i> | Kalamey Uniu | 5.26 | 0.39 |
| 39 | <i>Hedychium</i> sp. | Qiura | 5.26 | 0.26 |
| 40 | <i>Hedychium spicatum</i> | Gai sara | 5.26 | 0.79 |
| 41 | <i>Hemiphragma heterophyllum</i> | Nash jhar | 5.26 | 0.79 |
| 42 | <i>Holboellia angustifolia</i> | Gulfa | 2.63 | 0.54 |
| 43 | <i>Impatiens stenantha</i> | Mujuro | 5.26 | 0.39 |
| 44 | <i>Impatiens urticifolia</i> | Mujuro | 7.89 | 0.79 |
| 45 | <i>Lecanthus peduncularis</i> | Gagleto | 7.89 | 1.45 |
| 46 | <i>Leucostegia truncata</i> | Deer fern | 5.26 | 0.79 |
| 47 | <i>Lycopodium japonicum</i> | Nagbelli | 10.53 | 0.53 |
| 48 | <i>Microsorium membranaceum</i> | Uniu | 5.26 | 0.53 |
| 49 | <i>Mucuna macrocarpa</i> | Baldengro | 2.63 | 0.13 |
| 50 | <i>Nephrolepis cordifolia</i> | Pani amala | 2.63 | 0.26 |
| 51 | <i>Odontosoria chinensis</i> | Uneu | 2.63 | 0.26 |
| 52 | <i>Persicaria capitata</i> | Ratnaulo | 13.16 | 1.18 |
| 53 | <i>Piper</i> sp. | Chabo | 5.26 | 0.26 |
| 54 | <i>Plagiogyria pycnophylla</i> | Uniu | 13.16 | 0.92 |
| 55 | <i>Pleione praecox</i> | | 5.26 | 0.39 |
| 56 | <i>Pseudo-drynaria coronans</i> | Kamray lahara | 2.63 | 0.13 |
| 57 | <i>Pteris wallichiana</i> | Uneu | 5.26 | 0.39 |
| 58 | <i>Rhapidiphora decursiva</i> | Kanchirnu | 5.26 | 0.26 |
| 59 | <i>Rubia cordifolia</i> | Majito | 10.53 | 0.92 |
| 60 | <i>Rumex nepalensis</i> | Halhalley | 5.26 | 0.39 |
| 61 | <i>Schizandra neglecta</i> | Singatthey lahara | 2.63 | 0.13 |
| 62 | <i>Selaginella biformis</i> | Jhew | 10.53 | 1.05 |
| 63 | <i>Selaginella chrysocaulos</i> | Jhew | 15.79 | 1.97 |
| 64 | <i>Selaginella monospora</i> | Jhew | 7.89 | 0.92 |
| 65 | <i>Smilax</i> sp. | Madaney kara / Kirneyghans | 2.63 | 0.53 |
| 66 | <i>Solanum</i> sp. | | 15.79 | 1.03 |
| 67 | <i>Stephania glabra</i> | Tambarkay | 5.26 | 0.39 |
| 68 | <i>Strobilanthes</i> sp. | Kibughans | 10.53 | 0.92 |
| 69 | <i>Swertia bimaculata</i> | Bhaley chiraito | 15.79 | 1.97 |
| 70 | <i>Swertia chirayita</i> | Chiraito | 13.16 | 1.97 |
| 71 | <i>Urtica dioica</i> | Patley sisnu | 7.89 | 0.53 |
| 72 | <i>Xanthium strumarium</i> | Bhedekuro | 2.63 | 0.26 |

RE-GENERATION STATUS / FOREST HEALTH STATUS

Forest re-generation status or forest health status was analyzed on the basis of tree diameter class, wherein, the girth of the adult trees falling in diameter class below 30cm was found to be highest in density, followed by seedlings and saplings (Figure 5). The high availability of the seedlings, saplings and adult trees of DBH class above 121 cm in the forest shows that the status of the forest is stable. Likewise, the diameter class distribution for some of the dominant trees in the area has been represented in Plates I, II & III.

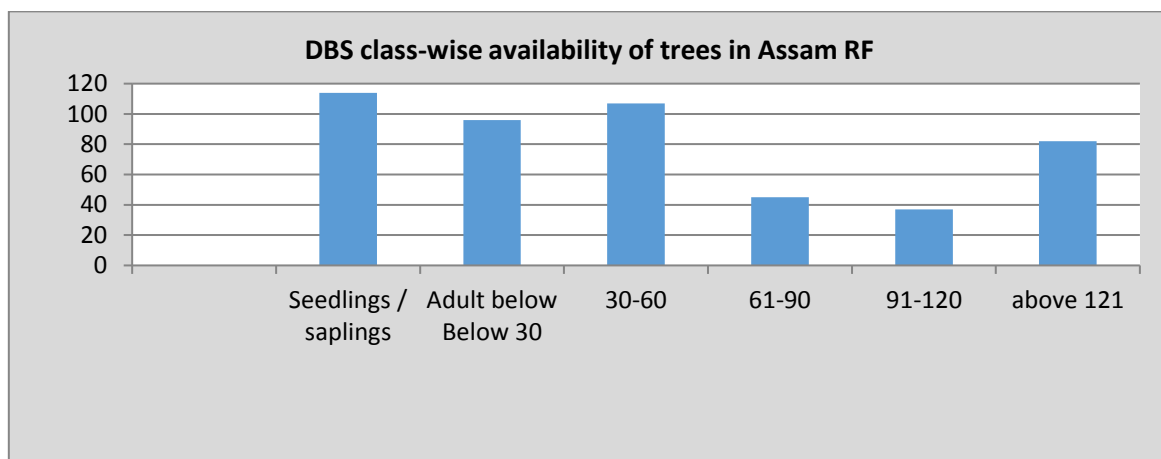


Figure 5: DBH class wise availability (in cm) of the available trees at Assam RF

The availability of the saplings of existing large trees species of the area was recorded very less for some species namely *Tetradium fraxinifolium*, *Elaeocarpus lanceifolius*, *Machilus edulis*, *Acer campbellii*, *Brassiopsis mitis*, *Quercus lamellosa* and *Hoveni aduicis* and to nil for some species namely *Acer pectinatum*, *Alangium begoniaefolium*, *Beilschmiedia sikkimensis*, *Castanopsis*

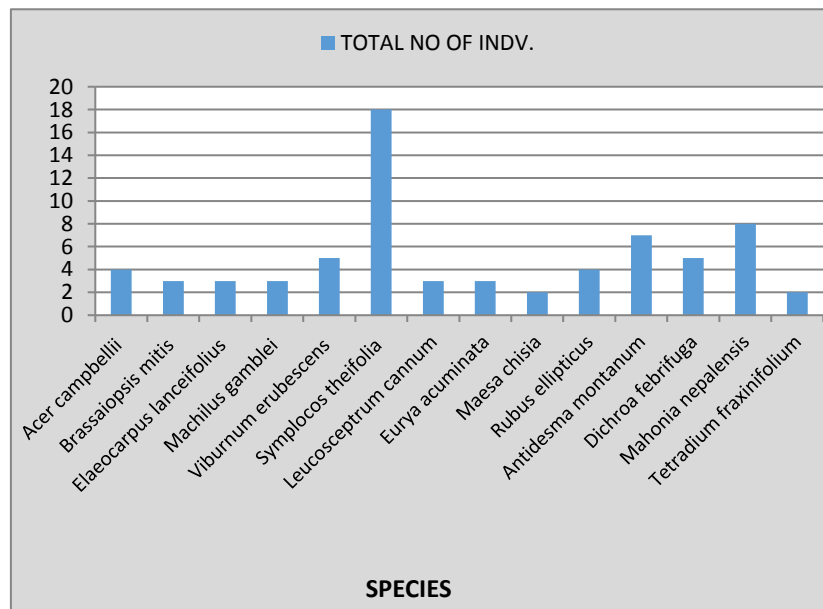


Figure 6: Availability and distribution of saplings in the sampled plot

tribuloides, *Cinnamomum impressinervium*, *Exbucklandia populnea*, *Ficus neriifolia*, *Garuga pinnata*, *Machilus edulis*, *Magnolia doltsopa*, *Nyssa sessiliflora*, *Quercus glauca* and *Rapanea capitellata*. The highest sapling density was recorded for small trees and shrubs namely *Maesa chisia*, *Rhododendron falconeri* and *Leucocephalum canum* followed by *Eurya acuminata*, *Pieris ovalifolia*, *Tetradium fraxinifolium* (**Figure 6**).

In the case of seedlings, the highest density was recorded for *Rhododendron falconeri* and *Symplocos theifolia* followed by *Eurya acuminata*, *Leucocephalum canum*, *Tetradium fraxinifolium*, etc. The seedlings of some of the existing large tree species was recorded with very less number of populations such as *Castanopsis tribuloides*, *Quercus lamellosa* and *Elaeocarpus lanceifolius*. For species such as *Beilschmiedia sikkimensis*, *Brassaiopsis mitis*, *Cinnamomum impressinervium*, *Erythrina arborescens*, *Ficus neriifolia*, *Hovenia dulcis*, *Machilus edulis*, *Nyssa sessiliflora*, *Quercus glauca* and *Rhododendron grande*, no seedlings were recorded in the sampled plots (**Figure 7**).

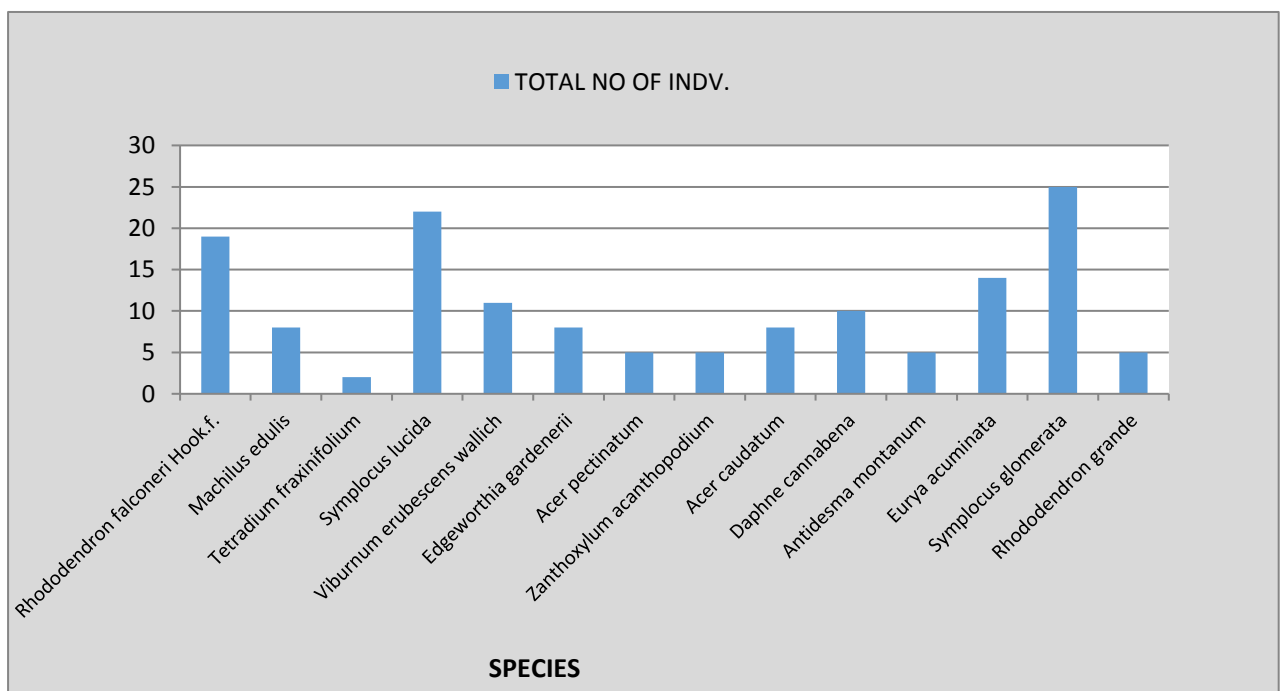


Figure 7: Availability and distribution of seedlings in the sampled plots

However, the availability of seedlings, saplings and small girth class trees of oak species was very less to almost nil in the forest; the diameter class distribution of existing oak species in the area has been represented in **Plate IV**.

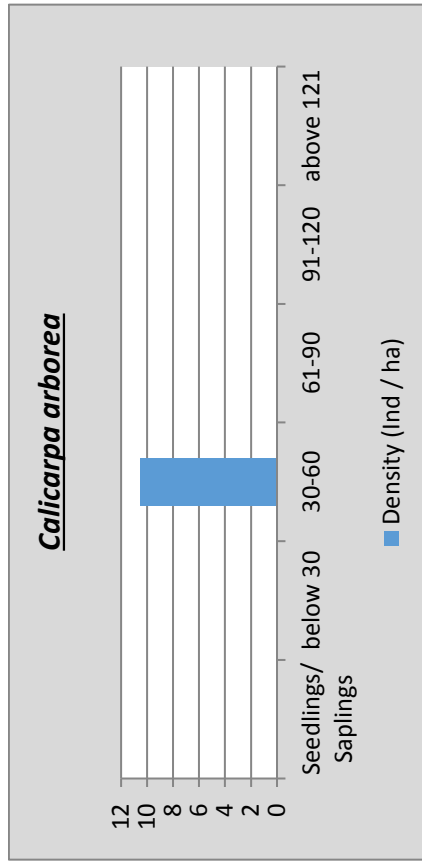
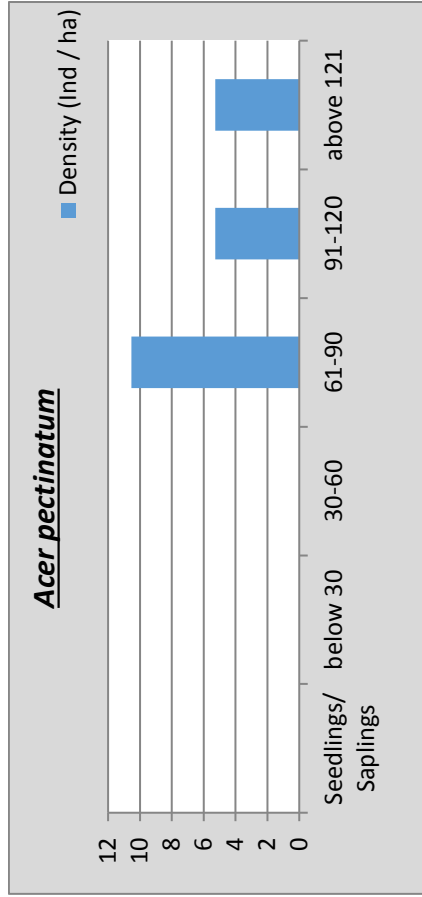
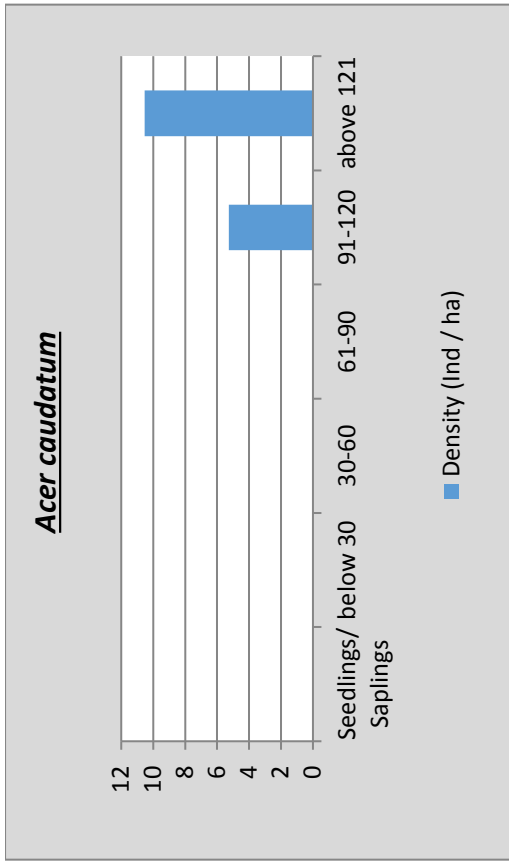
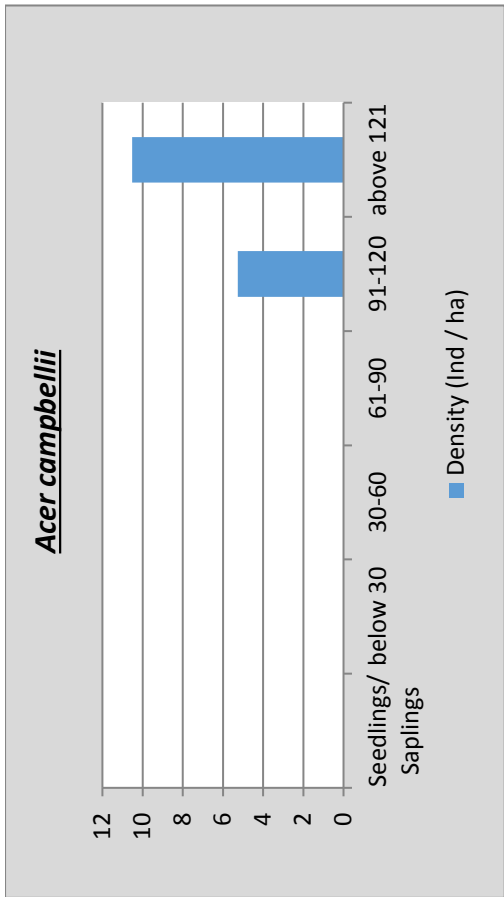


Plate I: Class wise availability (DBH class in cm) of some dominating species of Assam Reserve Forest

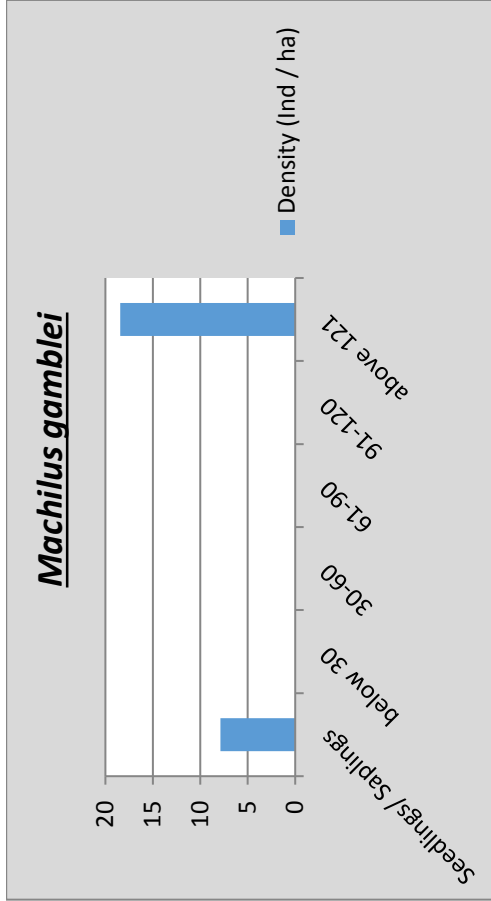
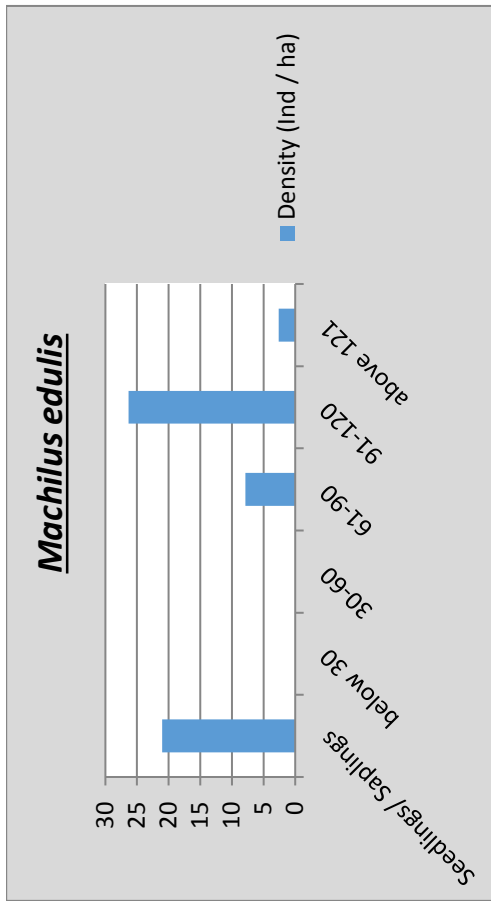
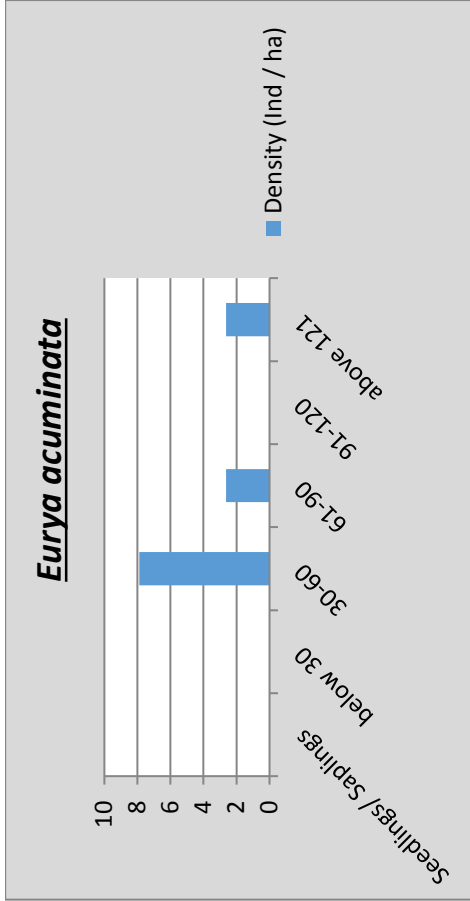
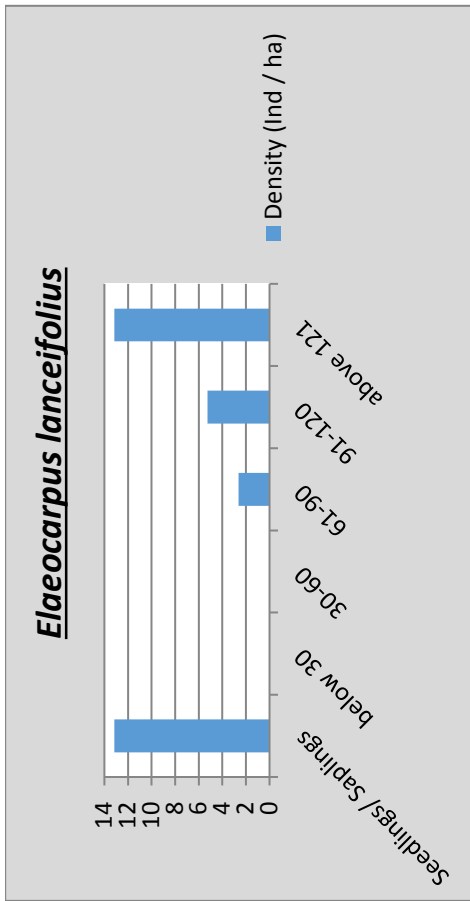


Plate II: Class wise availability (DBH class in cm) of some dominating species at Assam Reserve Forest

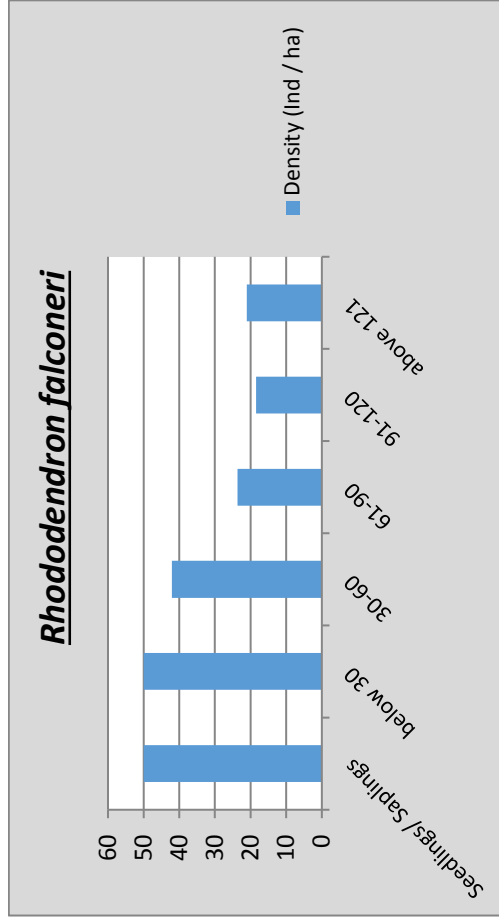
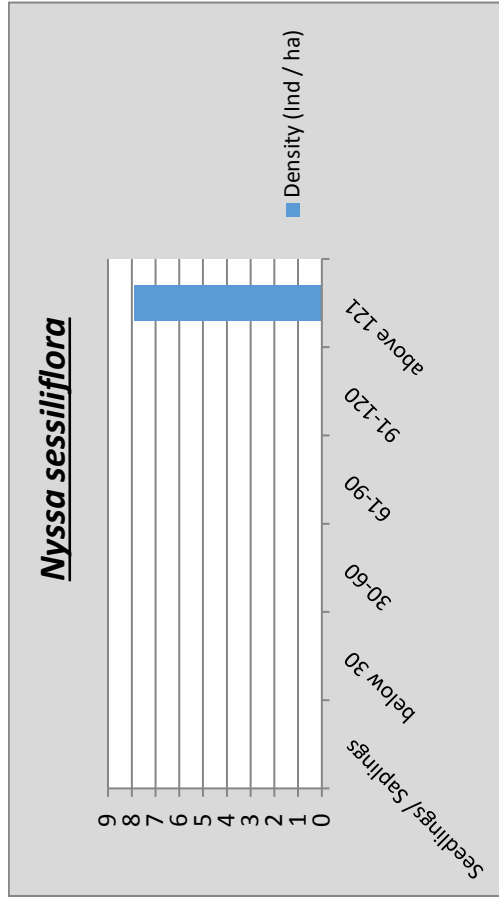
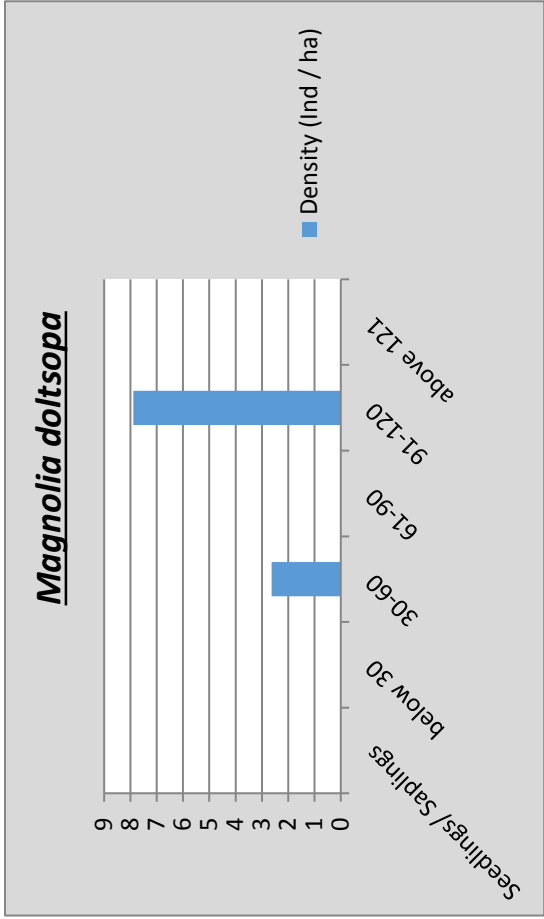
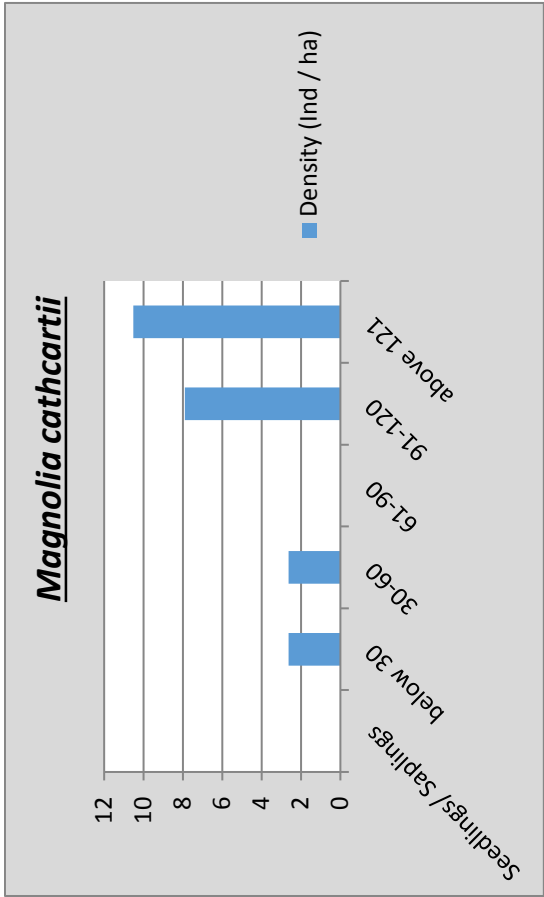


Plate III: Class wise availability (DBH class in cm) of some dominating species of Assam Reserve Forest

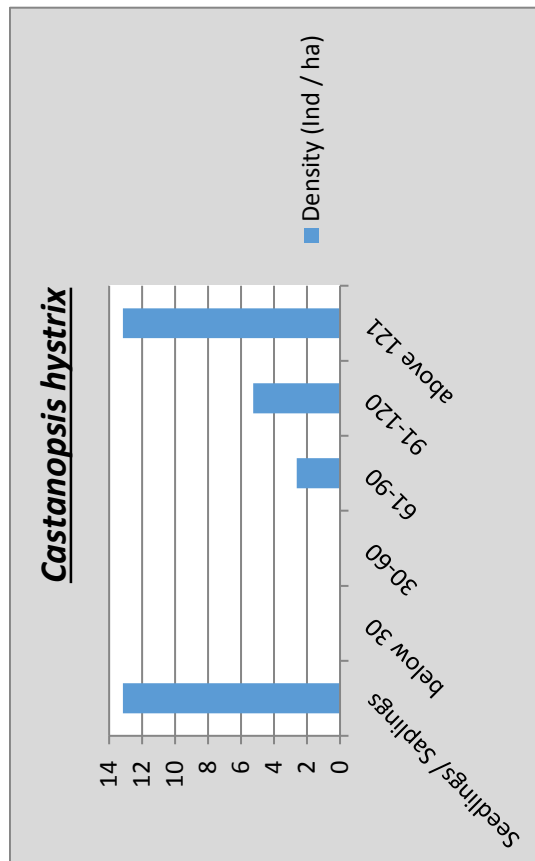
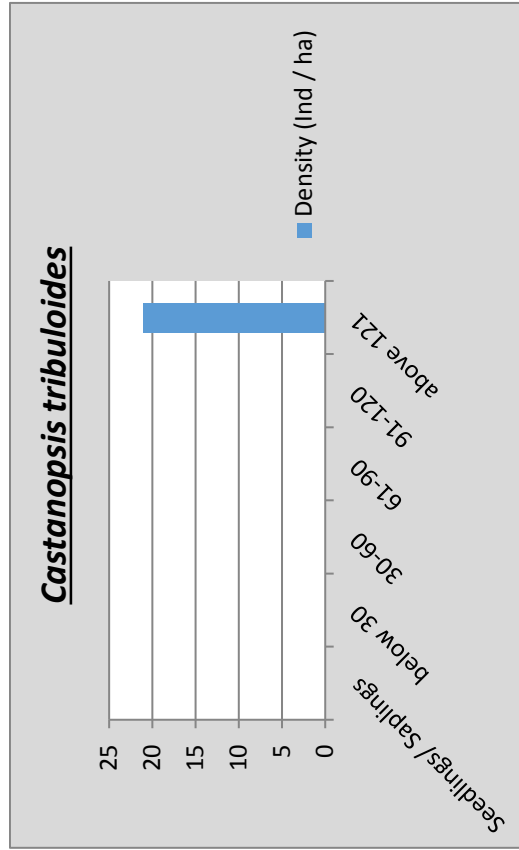
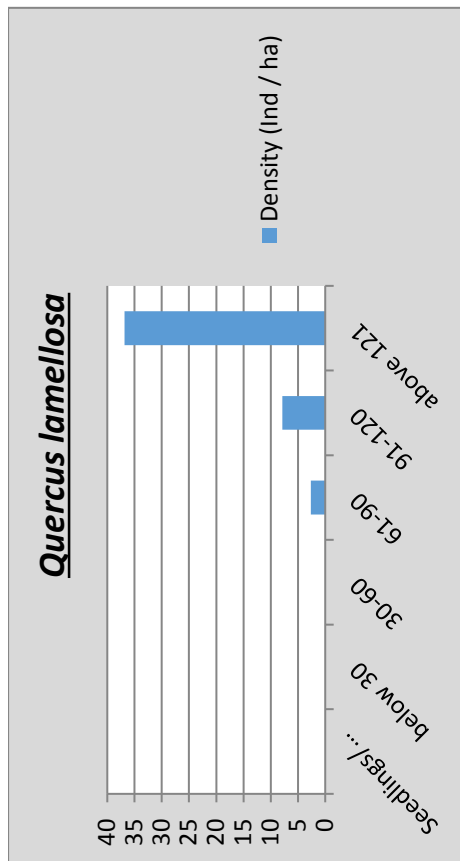
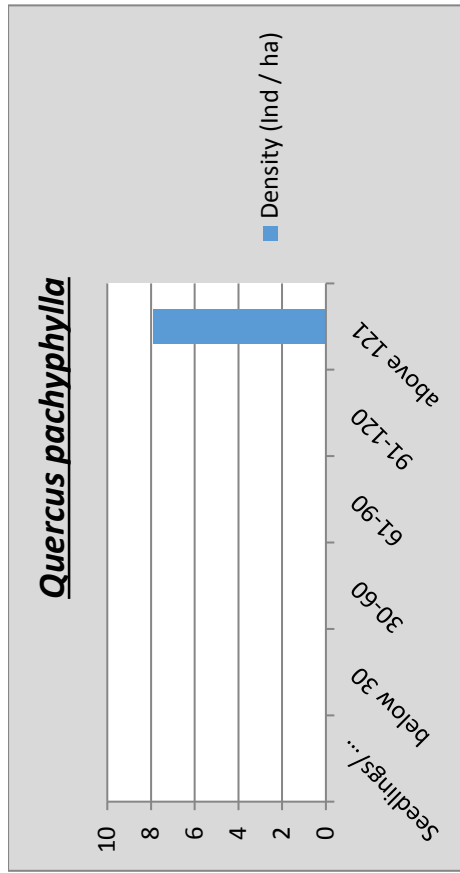


Plate IV: Class wise availability (DBH class in cm) of oak species at Assam Reserve Forest

Fauna

During the biodiversity survey in Assam Reserve forest, the existence of a total of 14 mammalian species, 52 bird species and 62 butterfly species were recorded through direct sightings and indirect evidences, which are listed in **Table 8**. Checklist of faunal species, including mammals, avi-fauna and butterflies of Assam RF and surrounding area in east Sikkim is represented in **Table 8**.

| Table 8: List of faunal species in Assam Reserve Forest, East Sikkim | | | |
|---|----------------------------------|---------------------------------|---------------|
| Sl.No | Common name | Scientific name | Family |
| Mammalian Species | | | |
| 1 | Jackel | <i>Cannis aurens</i> | Canidae |
| 2 | Himalayan serow | <i>Capricornis thar</i> | Bovidae |
| 3 | Parti-colored flying squirrel | <i>Hylopetes alboniger</i> | Sciuridae |
| 4 | Yellow-throated marten | <i>Martes flavigula</i> | Mustelids |
| 5 | Barking deer | <i>Muntiacus muntjak</i> | Cervidae |
| 6 | Goral | <i>Naemorhedus goral</i> | Bovidae |
| 7 | Himalayan palm civet | <i>Paguma larvata</i> | Viverridae |
| 8 | Wild pig | <i>Sus scrofa</i> | Suidae |
| 9 | Himalayan black bear | <i>Ursus thibetanus</i> | Ursidae |
| 10 | Himalayan crestless porcupine | <i>Hystrix brachyura</i> | Hystricidae |
| 11 | Hoary-bellied himalayan squirrel | <i>Callosciurus pygarythrus</i> | Sciuridae |
| 12 | Himalayan thar | <i>Hemitragus jemlahicus</i> | Bovidae |
| Avi – Fauna Species | | | |
| 1 | Ashy drongo | <i>Dicrurus leucophaeus</i> | Dicruridae |
| 2 | Barred cuckoo dove | <i>Macropygia unchall</i> | Columbidae |
| 3 | Blue whistling thrush | <i>Myophonus caeruleus</i> | Turdidae |
| 4 | Blue-fronted redstart | <i>Phoenicurus frontalis</i> | Muscicapidae |
| 5 | Blue-winged siva | <i>Siva cyanouroptera</i> | Timaliidae |
| 6 | Black bulbul | <i>Hypsipetes leucocephalus</i> | Pycnonotidae |
| 7 | Common green magpie | <i>Cissa chinensis</i> | Corvidae |
| 8 | Common hoopoe | <i>Upupa epops</i> | Upupidae |
| 9 | Common myna | <i>Acridotheres tristis</i> | Sturnidae |
| 10 | Common pigeon | <i>Columba libia</i> | Columbidae |
| 11 | Common-tailed bird | <i>Orthotomus sutorius</i> | Cisticolidae |
| 12 | Golden-breasted fulvetta | <i>Lioparus chrysotis</i> | Sylviidae |
| 13 | Great barbet | <i>Megalaima virens</i> | Ramphastidae |
| 14 | Greater yellownape | <i>Picus flavinucha</i> | Picidae |
| 15 | Green-backed tit | <i>Parus monticolus</i> | Paridae |
| 16 | Green-tailed sunbird | <i>Aethopyga nipalensis</i> | Nectariniidae |
| 17 | Grey-backed shrike | <i>Lanius tephronotus</i> | Laniidae |

| | | | |
|--------------------------|---------------------------------|------------------------------------|----------------|
| 18 | Grey-headed canary flycatcher | <i>Culicicapa ceylonensis</i> | Stenostiridae |
| 19 | Grey-headed parakeet | <i>Psittacula finschii</i> | Psittacidae |
| 20 | Himalayan bluetail | <i>Tarsiger rufilatus</i> | Muscicapidae |
| 21 | Himalayan bulbul | <i>Pycnonotus leucogenys</i> | Pycnonotidae |
| 22 | Hodgson's redstart | <i>Phoenicurus hodgsoni</i> | Muscicapidae |
| 23 | House crow | <i>Corvus splendens</i> | Corvidae |
| 24 | House sparrow | <i>Passer domesticus</i> | Passeridae |
| 25 | Kalij pheasant | <i>Lophura leucomelanos</i> | Phasianidae |
| 26 | Large-billed crow | <i>Corvus macrorhynchos</i> | Corvidae |
| 27 | Lesser yellownape | <i>Picus chlorolophus</i> | Picidae |
| 28 | Little spiderhunter | <i>Aracanothra longirostra</i> | Nectariniidae |
| 29 | Nepal fulvetta | <i>Alcippe nipalensis</i> | Sylviidae |
| 30 | Oriental magpie robin | <i>Copsychus saularis</i> | Muscicapidae |
| 31 | Oriental turtle dove | <i>Streptopelia orientalis</i> | Columbidae |
| 32 | Oriental white-eye | <i>Zosterops palpebrosus</i> | Zosteropidae |
| 33 | Red-billed leiothrix | <i>Leiothrix lutea</i> | Timaliidae |
| 34 | Red-tailed minla | <i>Minla ignotincta</i> | Leiothrichidae |
| 35 | Red-vented bulbul | <i>Pycnonotus cafer</i> | Pycnonotidae |
| 36 | Rufous sibia | <i>Malacias capistratus</i> | Timaliidae |
| 37 | Rufous-bellied niltava | <i>Niltava sundara</i> | Muscicapidae |
| 38 | Rufous-gorgeted flycatcher | <i>Ficedula strophiat</i> | Muscicapidae |
| 39 | Scaly laughingthrush | <i>Garrulax austeni</i> | Turdidae |
| 40 | Scarlet minivet | <i>Pericrocotus cinnamomeus</i> | Campephagidae |
| 41 | Silver-eared mesia | <i>Mesia argenteauris</i> | Leiothrichidae |
| 42 | Slender-billed Scimitar babbler | <i>Xiphirhynchus superciliaris</i> | Timaliidae |
| 43 | Spangled drongo | <i>Dicrurus hottentottus</i> | Dicruridae |
| 44 | Stripe-throated yuhina | <i>Yuhina gularis</i> | Zosteropidae |
| 45 | Velvet-fronted nuthatch | <i>Sitta frontalis</i> | Sittidae |
| 46 | Verditer flycatcher | <i>Eumyias thalassinus</i> | Muscicapidae |
| 47 | Whiskered yuhina | <i>Yuhina flavicollis</i> | Zosteropidae |
| 48 | White-browed fulvetta | <i>Fulvetta vinipectus</i> | Sylviidae |
| 49 | White-browed piculat | <i>Sasia ochracea</i> | Picidae |
| 50 | White-capped redstart | <i>Chaimarrornis leucocephalus</i> | Muscicapidae |
| 51 | White-crested laughingthrush | <i>Garrulax leucolophus</i> | Turdidae |
| 52 | Yellow-bellied fantail | <i>Chelidorhynch hypoxantha</i> | Rhipiduridae |
| Butterfly Species | | | |
| 1 | Autumn leaf | <i>Doleschallia bisaltidae</i> | Nymphalidae |
| 2 | Banded treebrown | <i>Lethe confuse</i> | Nymphalidae |
| 3 | Blue peacock | <i>Papilio acturus</i> | Papilionidae |
| 4 | Chocolate pansy | <i>Junonia iphita</i> | Nymphalidae |

| | | | |
|----|----------------------|--------------------------------|--------------|
| 5 | Common Bushbrown | <i>Mycalesis perseus</i> | Nymphalidae |
| 6 | Common cerculean | <i>Jamides celeno</i> | Lycaenidae |
| 7 | Common Crow | <i>Euploea core</i> | Nymphalidae |
| 8 | Common Earl | <i>Tanaecia julii</i> | Nymphalidae |
| 9 | Common Evening Brown | <i>Melanitis leda</i> | Nymphalidae |
| 10 | Common Five Ring | <i>Ypthima baldus</i> | Nymphalidae |
| 11 | Common Grass Yellow | <i>Eurema hecabe</i> | Pieridae |
| 12 | Common Jester | <i>Symbrenthia hippoclus</i> | Nymphalidae |
| 13 | Common Line Blue | <i>Posotas nora</i> | Lycaenidae |
| 14 | Common Map | <i>Cyrestis thyodamas</i> | Nymphalidae |
| 15 | Common Maplet | <i>Chersonesia risa</i> | Nymphalidae |
| 16 | Common Mormon | <i>Papilio polytes</i> | Papilionidae |
| 17 | Common Nawab | <i>Polyuria athamas</i> | Nymphalidae |
| 18 | Common Palmfly | <i>Elymnias hypermnestra</i> | Nymphalidae |
| 19 | Common Peacock | <i>Papilio polyctor</i> | Papilionidae |
| 20 | Common Pierrot | <i>Castalius rosimon</i> | Lycaenidae |
| 21 | Common Red Eye | <i>Matapa aria</i> | Hesperiidae |
| 22 | Common Red Forester | <i>Lethe mekara</i> | Nymphalidae |
| 23 | Common Sergeant | <i>Athyma perius</i> | Nymphalidae |
| 24 | Common Silverline | <i>Spindasis vulcans</i> | Lycaenidae |
| 25 | Common Small Flat | <i>Sarangesa dasahara</i> | Hasperiidae |
| 26 | Common Windmill | <i>Atrophaneura polyeuctes</i> | Papilionidae |
| 27 | Dark Judy | <i>Abisara fylla</i> | Riodinidae |
| 28 | Fluffy tit | <i>Zeltus amasa</i> | Lycaenidae |
| 29 | Fulvous pied Flat | <i>Pseudocoladenia dan</i> | Hesperiidae |
| 30 | Glassy Bluebottle | <i>Graphium sarpedon</i> | Papilionidae |
| 31 | Golden Sapphire | <i>Heliophorus brahma</i> | Lycaenidae |
| 32 | Grass Demon | <i>Udaspes folus</i> | Hesperiidae |
| 33 | Green Commodore | <i>Sumalia daraxa</i> | Nymphalidae |
| 34 | Indian Cabbage White | <i>Pieris canidia</i> | Pieridae |
| 35 | Indian Fritillary | <i>Argynnis hyperbius</i> | Nymphalidae |
| 36 | Indian Red Admiral | <i>Venessa indica</i> | Nymphalidae |
| 37 | Indian Skipper | <i>Spialian galba</i> | Hesperiidae |
| 38 | Indian Tortoiseshell | <i>Aglais cashmiriensis</i> | Nymphalidae |
| 39 | Large Yeoman | <i>Cirrochroa aoris</i> | Nymphalidae |
| 40 | Lemon Pansy | <i>Junonia lemonias</i> | Nymphalidae |
| 41 | Mixed Punch | <i>Dodona ouida</i> | Riodinidae |
| 42 | Nigger | <i>Orsotrioena medus</i> | Nymphalidae |
| 43 | Orange Oakleaf | <i>Kallima inachus</i> | Nymphalidae |
| 44 | Orange Punch | <i>Dodona egeon</i> | Riodinidae |
| 45 | Painted Lady | <i>Venessa carduii</i> | Nymphalidae |

| | | | |
|----|-------------------|--------------------------------|--------------|
| 46 | Plain tiger | <i>Danaus chrysippus</i> | Nymphalidae |
| 47 | Punchinello | <i>Zemeros flegyas</i> | Riodinidae |
| 48 | Purple sapphire | <i>Heliophorus epicles</i> | Lycaenidae |
| 49 | Red helen | <i>Papilio helenus</i> | Papilionidae |
| 50 | Red lacewing | <i>Cethosia biblustisamena</i> | Nymphalidae |
| 51 | Redbreast | <i>Papilio alcmenor</i> | Papilionidae |
| 52 | Rice swift | <i>Borbo cinnara</i> | Hesperiidae |
| 53 | Spotted sawtooth | <i>Prioneris thestylis</i> | Pieridae |
| 54 | Spotted snow flat | <i>Tagiades menaka</i> | Hesperiidae |
| 55 | Striped tiger | <i>Danaus genutia</i> | Nymphalidae |
| 56 | Tailed jay | <i>Graphium agamemnon</i> | Papilionidae |
| 57 | Tailed judy | <i>Abisara fylla</i> | Riodinidae |
| 58 | Tiger hooper | <i>Ochus subvittatus</i> | Hasperiidae |
| 59 | Water snow flat | <i>Tagiades litigiosa</i> | Hesperiidae |
| 60 | Yamfly | <i>Loxura atymnus</i> | Lycaenidae |
| 61 | Yellow helen | <i>Papilio nephelus</i> | Papilionidae |
| 62 | Yellow orange tip | <i>Ixias pyrene</i> | Peiridae |

DISCUSSION

The Assam Reserve Forest and adjacent area had remained unexplored till date, which, during the present study, found to be rich in terms of the diversity of the species. Forest density was also observed very high in most of the areas, followed by moderately dense. Forest being subtropical to temperate type, trees is the most predominant taxa in the area, followed by herbs, shrubs and shrublets, ferns, climbers and epiphytes. The area constitutes a diverse habitat for both flora and fauna of the subtropical to subalpine belt. The area is highly dominated with the trees and small trees species namely *Machilus odoratissimus*, *Machilus gammieana*, *Machilus gamblei*, *Machilus edulis*, *Quercus pachyphylla*, *Quercus lamellosa*, *Michelia excelsa*, *Michelia cathcartii*, *Gynocardia odorata*, *Elaeocarpus lanceaefolius*, *Symplocos theifolia* etc. followed by *Lithocarpus fenestrata*, *Castanopsis tribuloides*, *Castanopsis hystrix*, *Brassaiopsis mitis*, *Pyrularia edulis*, *Pieris ovalifolia*, *Michelia cathcartii*, *Maesa chisia*, *Antidesma acuminatum*, *Acer caudatum*, etc. In the higher altitudes areas, above Khedi, *Rhododendron falconeri*, *Rhododendron barbatum*, *Betula utilis* and *Yushania maling* were observed as the highly dominating species. Common shrub species recorded from the area are *Rubus ellipticus*, *Rubus niveus*, *Rubus paniculatus*, *Viburnum erubescens*, *Dichroa febrifuga*, *Maesa chisia*, *Oxyspora paniculata*, *Polygala arillata* etc. Diversity of the ground covering herbs species in the area recorded high, but in

terms of density, in term of the percentage of ground cover, was comparatively less. In addition, the area also provide diverse habitat for the faunal species.

Assam Reserve Forest is divided into five compartments. Compartment 1 is located in area above Thekabong, Deorali area, Dhajay, Hoday Dara and surrounding area (Figure & Table: Plots 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18). Compartment 2 is located in area below Gorujuray, towards Latape Dara above Assam Lingzey village, covering Parang Tar, Thonuki Goth area etc. (Figure & Table) : Plots 1, 2, 3, 4, 5, 6, 19, 20, 21, 22). Compartment 3 is located in area below Khedi (Figure & Table): Plots 23, 24, 25, 26). Copmpartment 4 is located in the Khedi area, which also includes the area adjacent to the Khedipokhari (Figure & Table): Plots 27, 28, 29, 30, 31, 32). Compartment 5 is located above Khedi upto the area below Menla (Figure & Table): Plots 33, 34, 35, 36, 37, 38).

Lower part of the survey area, in and around Latape Dara, ParengTaar, Thekabong and above, Deorali, upto Hoday Dara and surrounding area (1700-2400) meter elevation are highly covered with species namely *Machilus odoratissima*, *Machilus gammieana*, *Machilus gamblei*, *Machilus edulis*, *Quercus pachyphylla*, *Quercus lamellosa*, *Michelia excelsa*, *Michelia cathcartii*, *Gynocardia odorata*, *Elaeocarpus lanceaefolius*, *Symplocos theifolia*, *Lithocarpus fenestrata*, *Castanopsis tribuloides*, *Castanopsis hystrix*, *Brassaiopsis mitis*, *Pyrularia edulis*, *Pieris ovalifolia*, *Michelia cathcartii*, *Maesa chisia*, *Antidesma acuminatum*, *Acer caudatum*, *Antidesma acuminatum*, *Castanopsis hystrix*, *Castanopsis indica*, *Castanopsis tribuloides*, *Engelhardtia spicata*, *Eurya acuminata*, *Pieris ovalifolia*, *Symplocos theifolia*, *Symplocos glomerata*, *Dichroa febrifuga*, *Edgeworthia gardenerii*, *Rubus niveus*, *Rubus ellipticus*, *Viburnum erubescens*, *Rubus paniculatus*, etc. The area surrounding the Gorujuray and the area below Khedi (2400-2700) meter elevation are highly covered with *Elaeocarpus lanceaefolius*, *Symplocos theifolia*, *Quercus pachyphylla*, *Rhododendron falconeri*, *Rhododendron grandii*, *Yushania maling*, *Themnocalamus falconeri* with scattered *Acer pectinatum*, *Quercus lamellosa*, etc. In the upper belt of the forest, above 2800m, which is the area above Khedi, the forest canopy is less, and is dominated with *Betula utilis*, *Rhododendron barbatum*, *Rhododendron falconeri*, *Yushania maling*, etc (Table 9).

CONCLUSION AND RECOMMENDATIONS

The Assam Reserve Forest is not much impacted by the natural as well as anthropogenic disturbance. The floristic wealth of the area is rich and diverse, both in

composition and value but the re-generation of oak species and other big sized tree species recorded very less to almost nil in the very dense forests where canopy cover is more than 70%; which may be due to very less penetration of sunlight and air in the ground so the cultural thinning of the forest as well as massive plantation in the interior of the forest can be recommended. Intensity of threats to the biodiversity of the area has also been observed due to grazing pressure by cow (in lower and upper belt) and Yak (in the upper belt at Khedi and above areas). The unsustainable extraction of plants especially for firewood and livestock feed by the local inhabitants are the general disturbances which have resulted in the building up considerable pressure on the survival of species. Other major threats are obviously, the effect of drastic changes in climate, hence studies on the impact of climate change on the biodiversity of the area is recommended, which will be helpful in framing conservation and management strategies.



Coelogyne fuscescens



Magnolia dolstopa

Rapid Biodiversity Survey of Barapathing Reserve Forest, East Sikkim

Sabita Dahal, Meena Tamang and Suraj Subba



Photo 4: Natural habitat of *Acorus calamus* (Bojho)

STUDY AREA

A field trip for conducting Rapid Biodiversity Survey to Barapathing Reserve Forest in East Sikkim covering a sampling path from Latuk – Khedi –Thek in East Sikkim was carried out during October 2017 by the SBFP survey team. The trip was aimed for inventory and monitoring of the biodiversity of the area.

The present survey area along Latuk – Khedi –Thek sampling path, the forest type of which is represented by sub tropical to temperate forest with moderate to very dense canopy. The elevation range covered during the survey was from 1828m (Salalay Dara, above Latuk) to 2723m (Below Khedi) which is represented in **Figure 8a, 8b, 8c**. The slope angle of the area ranged between mild (5 degree) to steep (85 degree) slope and is facing towards E, NE, S and SE aspect (**Table 9**).

Forest being subtropical to temperate type, trees is the most predominant taxa in the area, followed by herbs, shrubs and shrublets, ferns, climbers and epiphytes. The area constitutes a diverse habitat for both flora and fauna of the subtropical to temperate belt. The area is highly dominated with the trees and small trees species namely *Symplocos theifolia* Don., *Lithocarpus fenestrata* Roxb., *Castanopsis tribuloides* (Smith) A. DC., *Castanopsis hystrix* Hook. & Thomson ex. A. DC., *Brassaiopsis mitis* C.B.Clarke, *Quercus pachyphylla* Kurz., *Quercus lamellosa* Smith., *Pyrularia edulis* (Wallich) A., *Pieris ovalifolia* D. Don, *Michelia cathcartii* Hook. f. Thomson, *Maesa chisia* Buch.-Ham.ex D. Don, *Machilus gammieana* King ex. Hook. f., *Antidesma acuminatum* Wight, *Acer caudatum* Wallich, etc. Common shrub species of the area are *Rubus ellipticus* Smith, *Rubus niveus* Thunb., *Rubus paniculatus* (Smith) Rees., *Viburnum erubescens* Wallich ex DC., *Dichroa febrifuga* Lour, *Maesa chisia* Don, *Oxyspora paniculata* (D.Don) DC, *Polygala arillata* Buch.- Ham ex D.Don, etc.

Barapathing Reserve Forest is divided into five compartments. Compartment 1 is located in the lower belt, sharing the boundary with Machong Reserve Forest in the southern part, Parakha Reserve Forest in the western part, Latuk village in the eastern part and Compartment 2 of Barapathing RF in the northern part. Compartment 2 shares its boundary with Parakha RF in the western part, Latuk village in the eastern part, compartment 1 of Barapathing RF in the southern part and Compartment 3 of the same in the northern side. The places namely Dareli, Kattike dara, Harakkatay dara is located in the Compartment 2 (**Figure 8a, Table 9**; Plots 39 and 41). Compartment 3 is located in the area above Latuk village and the portion of Taal Kharka area (**Figure 8a, Table 9**; Plots 1, 2, 11, 12, 16, 17, 18). Copmpartment 4 is located in the lower part of Malingay Kharka upto Dumphen Dara area, which shares its boundary in the north-western part with Assam RF (**Figure 8a, Table 9**; Plots 20, 21 22, 32, 33, 34, 35, 36). Compartment 5 is located in upper part of Malingay Kharka upto Khedi (**Figure 8a, Table 9**; Plots 23, 24, 25).

Lower part of the survey area, in and around Dumphen Dara, TaalKharka, area above Latuk and Thek, Harakkatay Dara, in between 1800-2100m elevation are highly covered with *Antidesma acuminatum*, *Castanopsis hystrix*, *Castanopsis indica*, *Castanopsis tribuloides*, *Engelhardtia spicata*, *Eurya acuminata*, *Pieris ovalifolia*, *Symplocos theifolia*, *Symplocos glomerata*, *Dichroa febrifuga*, *Edgeworthia gardenerii*, *Rubus niveus*, *Rubus ellipticus*, *Viburnum erubescens*, *Rubus paniculatus* etc. Area above Kattike Dara till the lower side of malinge Kharka, in between 2150m – 2600m, the area is efficiently covered with *Acer caudatum*, *Actinodaphne sikkimensis*, *Brassaiopsis mitis*, *Cedrela febrifuga*, *Elaeocarpus lanceaefolius*, *Garuga pinnata*, *Glochidion acuminatum*, *Gynocardia odorata*, *Machilus edulis*, *Machilus gamblei*, *Machilus gammieana*, *Machilus odoratissimus*, *Michelia cathcarti*, *Michelia excels*, *Myrica esculenta*, *Nyssa sessiliflora*, *Rhus succedanea*, *Rhus succedanea* Linn.var. *acuminata*, *Daphne cannabina*, *Themnocalamus falconeri*, *Dichroa febrifuga* and so on. In the upper belt of the forest, above 2600m, which is the area below Khedi, and the upper side of MalingeKharka, the area is highly dominated with *Rhododendron falconeri* and *Yushania maling* with scattered *Acer pectinatum*, *Quercus lamellosa*, etc (**Photo 5**). Species composition and forest density of Assam RF and Barapathing RF are almost the same, which may be due to the fact that altitudinal range, slope angle and slope aspect of both the RF is almost the same, and also these two forests are sharing the boundary from the middle belt, till the upper belt.

Forest harbours common mammals such as Jackel, Squirrel, Goral, Himalayan palm civet, Wild pig etc.; avi-faunal species such as Common pigeon, Common myna, Great barbet, Himalayan bulbul, House crow, House sparrow, Kalij pheasant, Large-billed crow, Oriental turtle dove, Oriental white-eye ashly drongo, Verditer flycatcher, Red-tailed minla, etc.



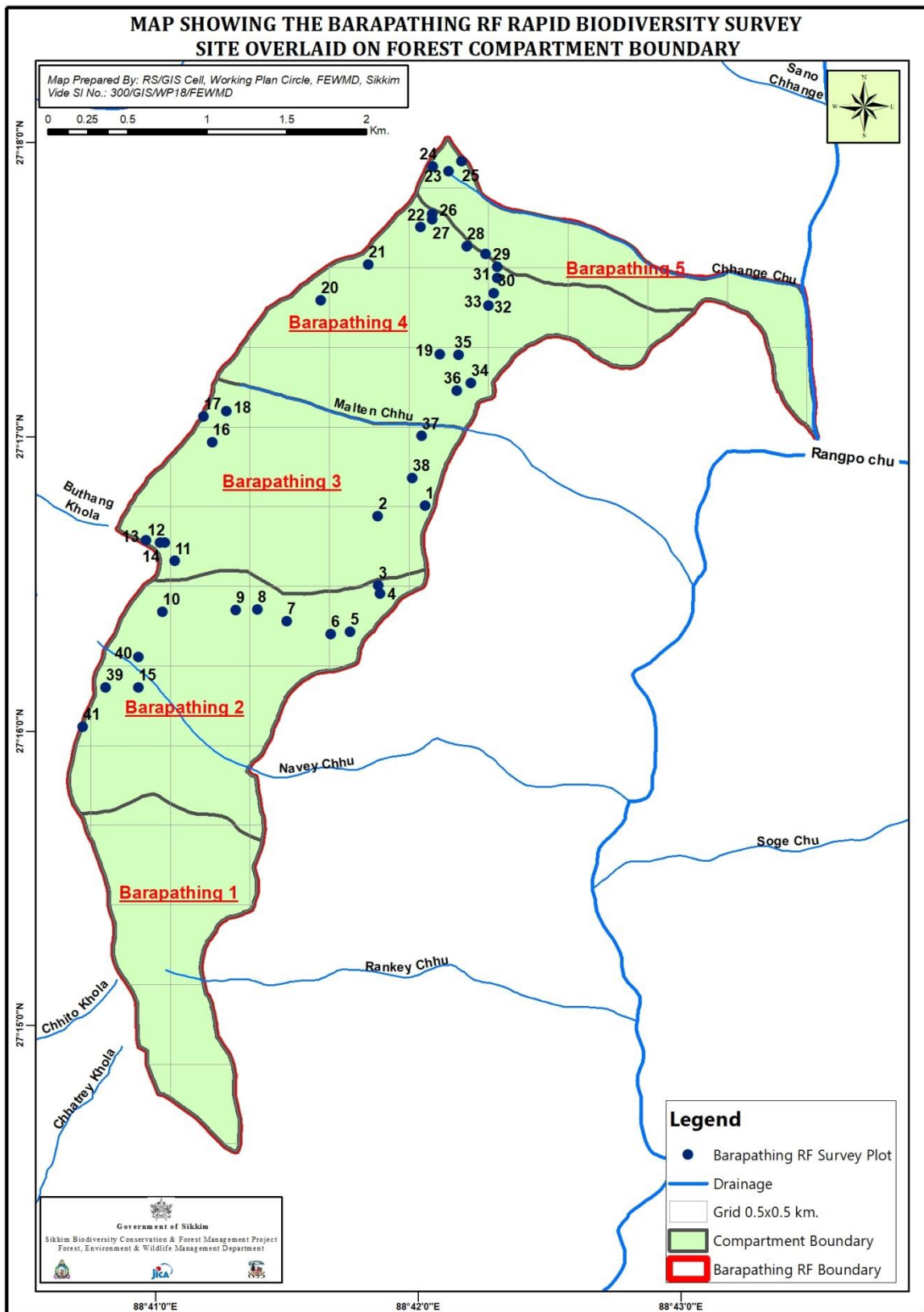


Figure 8a: Rapid biodiversity survey plots along Latuk – Khedi –Thek sampling path showing forest density

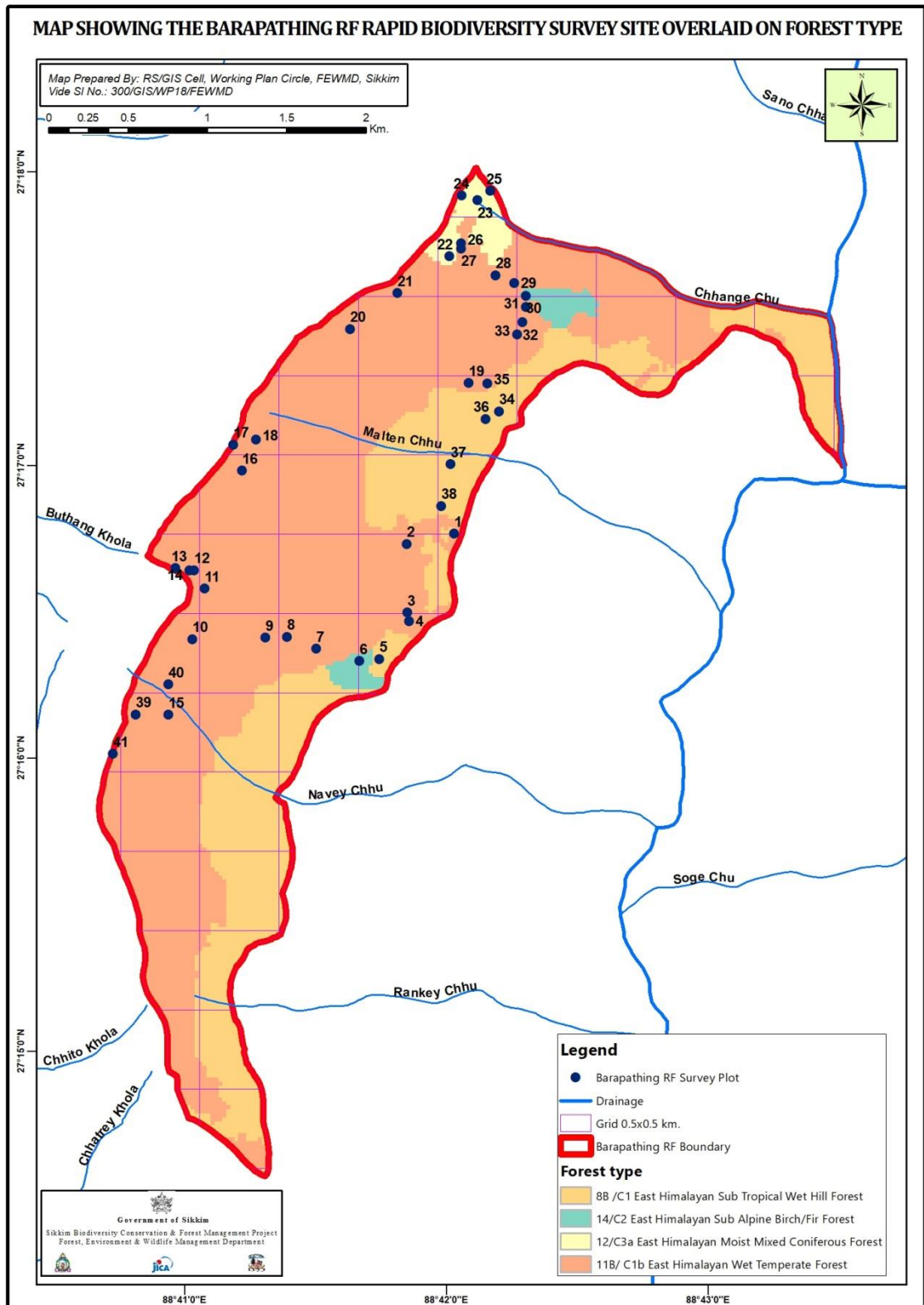


Figure 8b: Rapid biodiversity survey plots along Latuk – Khedi – Thek sampling path showing forest type

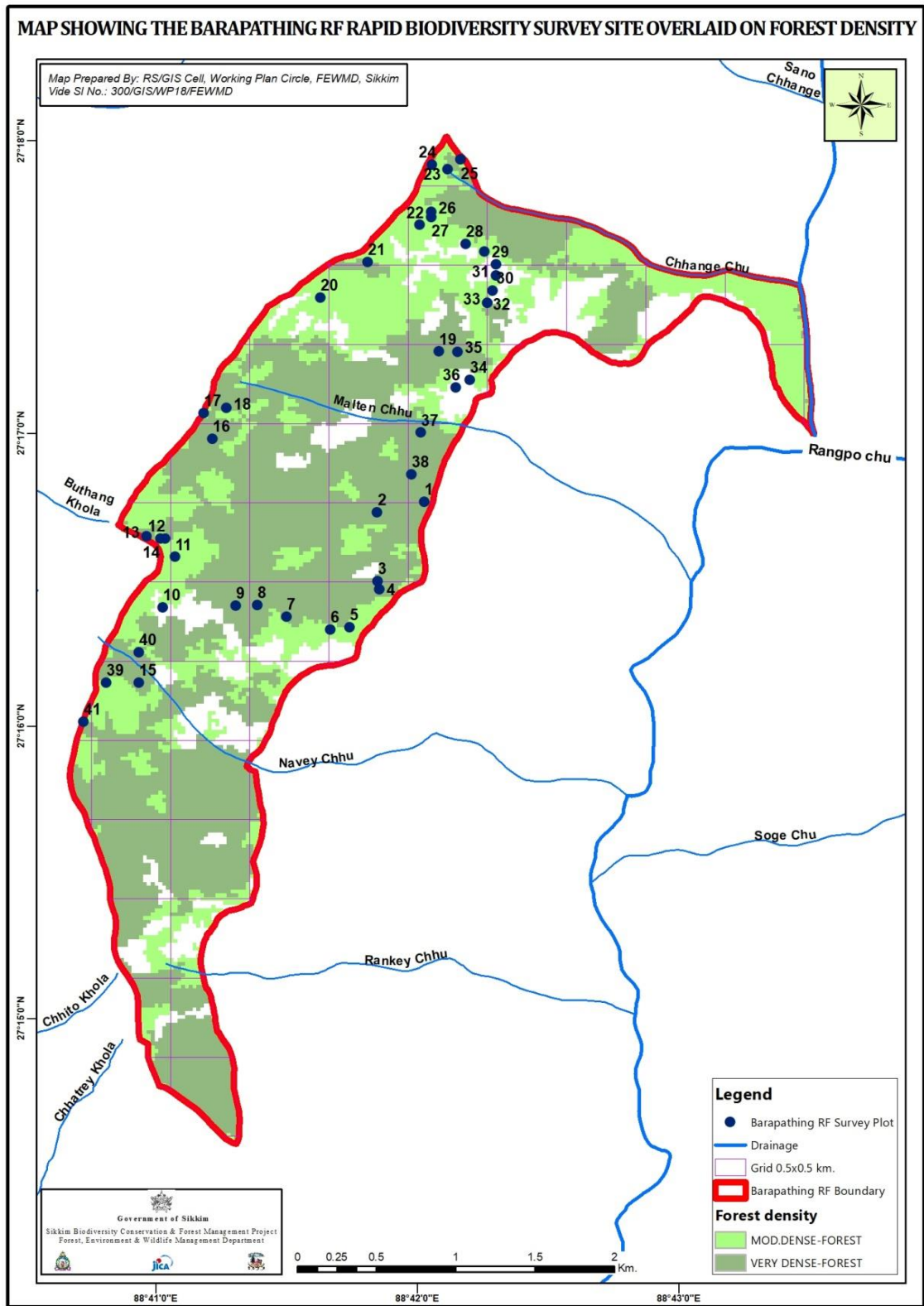


Figure 8c: Rapid biodiversity survey plots along Latuk – Khedi – Thek sampling path showing forest density

| Site Code | Forest type | Elevation (m) | GPS co-ordinates | | Slope angle (°) | Slope aspect | Canopy cover, Forest density | Dominant taxa | Disturbances | Location name |
|-----------|---------------|---------------|------------------|-----------|-----------------|--------------|------------------------------|------------------|--------------|----------------|
| | | | Latitude | Longitude | | | | | | |
| Plot1 | Wet Temperate | 1828 | 271649.1 | 884150.8 | 30 | E | 90%, Very dense | Trees | Nil | Above Latuk |
| Plot2 | Wet Temperate | 1951 | 271647.1 | 884140 | 30 | E | 60%, Moderately dense | Trees | Grazing | Taal Kharika |
| Plot3 | Wet Temperate | 2007 | 271633 | 884139.9 | 45 | E | 60%, Moderately dense | Trees | Grazing | Taal Kharika |
| Plot4 | Wet Temperate | 2038 | 271631.3 | 884140.2 | 30 | E | 50%, Moderately dense | Trees | Nil | Harkattay Dara |
| Plot5 | Wet Temperate | 2105 | 271623.6 | 884133.3 | 40 | E | 50%, Moderately dense | Trees | Nil | |
| Plot6 | Wet Temperate | 2109 | 271623.2 | 884128.8 | 45 | E | 75%, very dense | Trees | Nil | Kattike Dara |
| Plot7 | Wet Temperate | 2207 | 271625.9 | 884118.9 | 45 | E | 40%, Moderately dense | Trees | Nil | |
| Plot8 | Wet Temperate | 2248 | 271628.4 | 884112.2 | 45 | E | 45%, Moderately dense | Trees | Nil | |
| Plot9 | Wet Temperate | 2287 | 271628.3 | 884107.2 | 30 | E | 55%, Moderately dense | Trees | Nil | |
| Plot10 | Wet Temperate | 2347 | 271628.2 | 884050.5 | 5 | NW | 0%, open | Herbs | Grazing | Dareli |
| Plot11 | Wet Temperate | 2446 | 271638.5 | 884053.5 | 30 | NE | 50%, Moderately dense | Trees | Nil | Above Dareli |
| Plot12 | Wet Temperate | 2494 | 271640.2 | 884047.8 | 30 | NE | 40%, Moderately dense | Trees | Nil | Above Dareli |
| Plot13 | Wet Temperate | 2537 | 271640.7 | 884043.5 | 35 | NE | 90%, very dense | Trees | Nil | Above Dareli |
| Plot14 | Wet Temperate | 2540 | 271640.2 | 884046.7 | 30 | NE | 50%, Moderately dense | Trees | Nil | Above Dareli |
| Plot15 | Wet Temperate | 2551 | 271612.8 | 884044.8 | 45 | NE | 90%, very dense | Trees | Nil | Above Dareli |
| Plot16 | Wet Temperate | 2565 | 271702.6 | 884102.4 | 60 | NE | 90%, very dense | Trees | Nil | Above Dareli |
| Plot17 | Wet Temperate | 2577 | 271730.2 | 884050.5 | 50 | NE | 80%, very dense | Trees | Nil | |
| Plot18 | Wet Temperate | 2593 | 271708.9 | 884105.7 | 60 | E | 75%, very dense | Trees | Nil | |
| Plot19 | Wet Temperate | 2600 | 271719.7 | 884154.6 | 70 | E | 70%, very dense | Bamboo (Malingo) | Nil | Below Khedi |
| Plot20 | Wet Temperate | 2648 | 271731.3 | 884127.6 | 70 | E | 50%, Moderately dense | Bamboo (Malingo) | Nil | Below Khedi |
| Plot21 | Wet Temperate | 2649 | 271738.5 | 884138.6 | 70 | E | 90%, very dense | Trees | Nil | Below Khedi |
| Plot22 | Wet Temperate | 2695 | 271745.9 | 884150.6 | 70 | E | 90%, very dense | Trees | Nil | Below Khedi |

| | | | | | | | | | | |
|---------|---------------|------|----------|----------|----|----|-----------------------|------------------|-----|--------------------------|
| Plot23 | Wet Temperate | 2639 | 271757.3 | 884157.2 | 70 | E | 90%, very dense | Trees | Nil | Below Khedi |
| Plot24 | Wet Temperate | 2629 | 271758.3 | 884153.6 | 70 | E | 70%, very dense | Trees | Nil | Below Khedi |
| Plot25 | Wet Temperate | 2723 | 271759.2 | 884200.2 | 70 | E | 70%, very dense | Trees | Nil | Below Khedi |
| Plot26 | Wet Temperate | 2655 | 271748.5 | 884153.3 | 60 | E | 80%, very dense | Trees | Nil | Malingay Kharka (Top) |
| Plot27 | Wet Temperate | 2631 | 271747.5 | 884158.1 | 70 | E | 50%, Moderately dense | Bamboo (Malingo) | Nil | Malingay Kharka |
| Plot28 | Wet Temperate | 2586 | 271741.9 | 884201.1 | 70 | S | 90%, very dense | Trees | Nil | Malingay Kharka |
| Plot29 | Wet Temperate | 2535 | 271740.3 | 884205.4 | 70 | SE | 90%, very dense | Trees | Nil | Malingay Kharka |
| Plot30 | Wet Temperate | 2477 | 271737.6 | 884208 | 50 | S | 90%, very dense | Trees | Nil | Malingay Kharka |
| Plot31 | Wet Temperate | 2429 | 271735.3 | 884212.4 | 70 | S | 90%, very dense | Trees | Nil | Malingay Kharka |
| Plot32 | Wet Temperate | 2354 | 271732.2 | 884207.2 | 30 | SE | 50%, moderately dense | Bamboo (Malingo) | Nil | Malingay Kharka |
| Plot33 | Wet Temperate | 2318 | 271729.7 | 884205.9 | 50 | SE | 70%, very dense | Bamboo (Malingo) | Nil | Malingay Kharka |
| Plot34 | Wet Temperate | 2215 | 271724 | 884201.6 | 45 | S | 80%, very dense | Trees | Nil | |
| Plot35 | Wet Temperate | 2119 | 271719.8 | 884158.9 | 40 | SE | 90%, very dense | Trees | Nil | Dumphen Dara |
| Plot36 | Wet Temperate | 2054 | 271712.5 | 884158.4 | 70 | SE | 50%, moderately dense | Trees | Nil | |
| Plot 37 | Wet Temperate | 1919 | 271703.3 | 884150.2 | 30 | SE | 45%, moderately dense | Trees | Nil | |
| Plot 38 | Wet Temperate | 1859 | 271654.8 | 884148 | 50 | SE | 40%, moderately dense | Trees | Nil | Above Thek |
| Plot 39 | Wet Temperate | 2371 | 271588.6 | 884025 | 30 | W | 85%, very dense | Trees | Nil | Near Dareli |
| Plot 40 | Wet Temperate | 2357 | 271619.5 | 884044.3 | 30 | W | 90%, very dense | Trees | Nil | Boundary to private land |
| Plot 41 | Wet Temperate | 2315 | 271604.3 | 884032.8 | 45 | NW | 85%, very dense | Trees | Nil | |

RESULT AND DISCUSSION

Flora

During the survey in Barapathing Reserve Forest, a total of 41 sample plots were laid covering 0.41 ha area (**Table 9**; **Figure 8a, b, c**) from which 30 species of trees, 4 species of bamboos, 16 species of shrubs, 72 species of herbs (including ferns) were recorded and are marked with (*) in **Annexure 2**. A general checklist of the floral species of the area (including the areas outside of the plots) were prepared of which, trees and small trees represented the highest number of species (66 species) followed by herbs (60 species), 31 species of climbers and epiphytes, 19 species of shrubs and shrublets, 26 number of ferns and fern allies, 9 number of bamboos and cane were recorded from the area during the present study (**Table 10**). Plot-wise location name, dominant taxa, elevation, GPS-co-ordinates, forest type, slope angle, slope aspect, disturbances and forest density of the area in terms of canopy cover in and around the sample plots are provided in the **Table 9**.

Family-wise analysis of the tree / small tree species revealed that of the total number of Lauraceae and Fagaceae was the dominant species with 8 and 7 species, respectively (**Figure 9**). In case of ground vegetation (shrubs and herbs including climbers, creepers, ferns, bamboos etc.), Urticaceae and Poaceae were the dominant species followed by Polypodiaceae, Rosaceae, Pteridaceae, Woodsiaceae, Asteraceae, etc. (**Figure 10**).

| Habit | Species | Genus | Family |
|--------------------------------------|------------|------------|------------|
| Trees and Small trees / large shrubs | 66 | 50 | 32 |
| Shrubs / shrublets | 19 | 14 | 10 |
| Herbs | 60 | 45 | 28 |
| Epiphytes / Climbers | 31 | 25 | 21 |
| Ferns / Fern allies | 26 | 21 | 15 |
| Bamboo and Cane | 9 | 9 | 3 |
| Total | 213 | 164 | 109 |



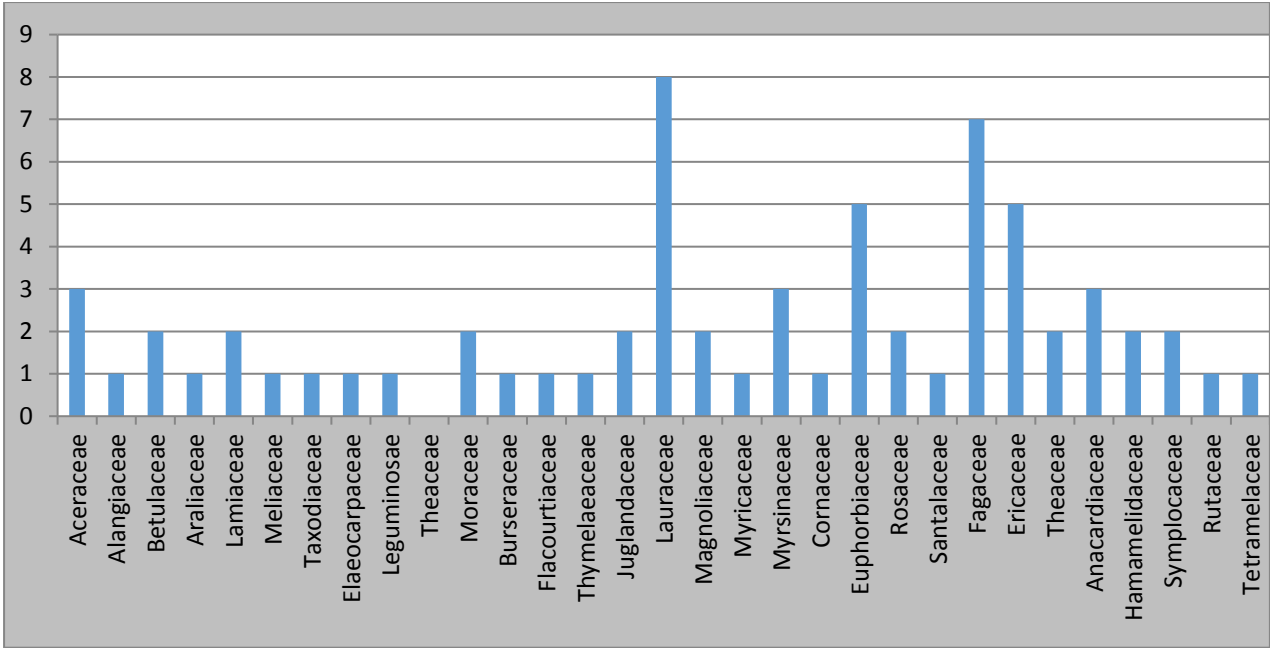


Figure 9: Family-wise distribution of tree species

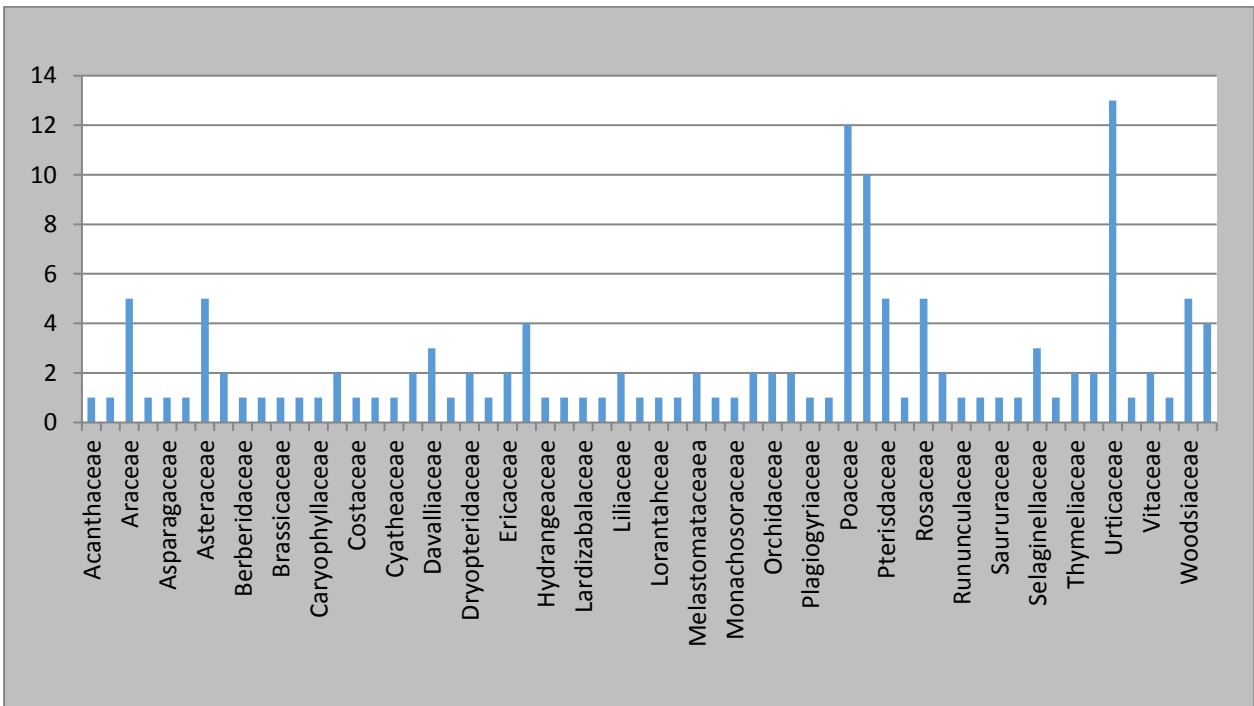


Figure 10: Family-wise distribution of ground vegetation including small shrubs, herbs, climbers, creepers and ferns

POPULATION FIGURE OF THE FLORAL SPECIES IN BARAPATHING RESERVE FOREST

Trees / Small Trees / Large Shrubs Species

In the case of adult trees, *Castanopsis tribuloides* was the dominant species in the lower belt with the highest cumulative adult stem density of 152.632 ± 58.2568 ind/ha and total basal cover of $5723.03\text{m}^2/\text{ha}$, whereas *Rhododendron falconeri* was the dominant tree in the upper belt with the highest cumulative adult stem density (121.053 ± 89.7925 ind/ha) as well as the total basal cover of $1404.45\text{m}^2/\text{ha}$ followed by *Quercus lamellosa* (39.474 ± 23.8684 ind/ha; $1804.03\text{m}^2/\text{ha}$), *Lyonia ovalifolia* (28.947 ± 65.6333 ind/ha; $76.51\text{m}^2/\text{ha}$), *Magnolia doltsopa* (26.316 ± 35.5409 ind/ha; $104.21\text{m}^2/\text{ha}$), *Symplocos theifolia* (94.737 ± 65.2771 ind/ha; $177.26\text{m}^2/\text{ha}$) and so on (**Table 11; Figure 11**). However, some species has been recorded with very less number of population such as *Acer pectinatum* with adult stem density of 5.26 ind/ha, *Cinnamomum obtusifolium*, *Exbucklandia populnea*, *Ficus nerifolia*, *Garuga pinnata*, *Hovenia dulcis*, *Nyssa sessiliflora* and *Rhododendron grande* of 2.63 ind/ha. Along the upper region of the forest, *Yushania maling* appeared as highly dominating species. *Yushania maling* is bamboo species; however, the species cannot be ignored while conducting population estimation because it is the highly dominating species in the upper belt of temperate forest. For the species of bamboos, the number of clumps was counted to analyze population in terms of Individual Plant Density per Ha. The availability and distribution of the tree species including saplings and seedlings in the area in terms of Density, Total Basal Cover (TBC), Abundance Frequency ratio (A/F ratio), important value index (IVI) are represented in the **Tables 11 & 12**.

| Table 11: Availability and distribution of tree and bamboo species (highly dominating taxa) in Barapathing RF, East Sikkim | | | | | | | | | | |
|--|---------------|------------------|-----------------|--------------------------|-----------|--------|------------------|------------------|-----------|--|
| Species | Local name | Adult | | | | | Saplings | | Seedlings | |
| | | Density (ind/ha) | SE (density)/ha | TBC (m ² /ha) | A/F Ratio | IVI | Density (ind/ha) | Density (ind/ha) | | |
| <i>Acer campbellii</i> Hook.f. & Thomson ex Hiern | Kapasay | 5.263 | 22.629 | 256.66 | 0.760 | 6.658 | 15.789 | 39.474 | | |
| <i>Acer pectinatum</i> Wall. | Lek kapasey | 5.263 | 16.001 | 284.98 | 0.190 | 5.254 | | 7.895 | | |
| <i>Alangium begoniaefolium</i> (Roxb.) Baill | Akhanay | 7.895 | 15.778 | 44.49 | 0.127 | 3.495 | | 7.895 | | |
| <i>Beilschmiedia sikkimensis</i> King exHook.f. | Tarsing | 7.895 | 25.371 | 107.35 | 0.285 | 43.098 | | | | |
| <i>Brassaiopsis mitis</i> C.B.Clarke | Phutta | 23.684 | 25.880 | 178.01 | 0.095 | 8.395 | 5.263 | | | |
| <i>Castanopsis tribuloides</i> (Smith) A. DC. | Murray katus | 152.632 | 58.257 | 5723.03 | 0.076 | 81.743 | | 2.632 | | |
| <i>Cinnamomum impressinervium</i> Meisn. | Sinkauli | 2.632 | 16.222 | 10.27 | 0.380 | 1.127 | | | | |
| <i>Drepanostachyum intermedium</i> | Titay nigalo | 78.947 | 321.381 | | 3.420 | 8.306 | | | | |
| <i>Elaeocarpus lanceifolius</i> Roxb. | Bhadrasay | 13.158 | 40.839 | 39.66 | 0.475 | 3.079 | 21.053 | 5.263 | | |
| <i>Erythrina arborescens</i> Roxb | Phaledo | 2.632 | 16.222 | 10.86 | 0.380 | 1.132 | | | | |
| <i>Eurya acuminata</i> DC. | Jhingani | 10.526 | 35.978 | 11.54 | 0.380 | 2.623 | 36.84 | 62.31 | | |
| <i>Exbucklandia populnea</i> (R. Br. ex Griff.) R.W. Br. | Piplee | 2.632 | 16.222 | 130.95 | 0.380 | 2.129 | | 7.89 | | |
| <i>Ficus nerifolia</i> Sm. | Dudilo | 2.632 | 16.222 | 11.79 | 0.380 | 1.139 | | | | |
| <i>Garuga pinnata</i> Roxb. | Dabdabay | 2.632 | 16.222 | 67.88 | 0.380 | 1.605 | | 11.56 | | |
| <i>Themnocalamus falconeri</i> Hook.f.ex.Munro. | Singanay bans | 47.368 | 95.613 | | 0.760 | 6.459 | | | | |
| <i>Himalayacalamus hookerianus</i> (Munro) Stepleton | Paryang | 10.526 | 32.003 | | 0.380 | 2.528 | | | | |

| | | | | | | | | |
|---|------------------------|---------|---------|---------|-------|--------|--------|---------|
| <i>Hovenia dulcis</i> Thunb. | Bangi | 2.632 | 16.222 | 42.25 | 0.380 | 1.392 | 5.263 | |
| <i>Leucoscepttrum canum</i> Sm. | Ghurpis | 15.789 | 58.185 | 71.03 | 0.570 | 3.562 | 55.26 | 72.05 |
| <i>Pieris ovalifolia</i> D. Don. | Angeri | 28.947 | 65.633 | 76.52 | 0.464 | 5.538 | 34.21 | 54.18 |
| <i>Machilus edulis</i> King. | Funchey / Pumsi | 7.895 | 25.371 | 73.24 | 0.285 | 3.306 | | |
| <i>Machilus gamblei</i> King ex J. D. Hooker | Lapche kaulo | 7.895 | 15.778 | 93.24 | 0.127 | 4.614 | 10.526 | 34.211 |
| <i>Magnolia doltsopa</i> (Buch.-Ham. ex DC.) Figlar | Rani chanp | 26.316 | 35.541 | 104.21 | 0.152 | 7.186 | | 10.526 |
| <i>Mahonia napaulensis</i> DC | Chutro | 2.632 | 16.222 | 13.41 | 0.380 | 1.153 | | |
| <i>Nyssa sessiliflora</i> Hook. f. & Thomson ex Benth | Lek chilauney | 2.632 | 16.222 | 383.39 | 0.380 | 4.224 | | |
| <i>Quercus glauca</i> Thunb. | Phalant | 7.895 | 25.371 | 124.66 | 0.285 | 3.340 | | |
| <i>Quercus lamellosa</i> Smith. | Buk / Bajrant | 39.474 | 23.868 | 1804.04 | 0.057 | 11.679 | 5.263 | 2.631 |
| <i>Rapanea capitellata</i> (Wall.) Mez | Seti kath (900-1800m) | 13.158 | 26.435 | 167.11 | 0.119 | 5.777 | | |
| <i>Rhododendron falconeri</i> Hook.f. | Korlingo | 121.053 | 89.793 | 1404.46 | 0.146 | 36.759 | 53.15 | 144.736 |
| <i>Rhododendron grande</i> Wright. | Patle korlingo | 2.632 | 16.222 | 8.85 | 0.380 | 1.115 | | |
| <i>Rhus</i> sp. | Kag valayo | 7.895 | 25.371 | 16.66 | 0.285 | 2.444 | 11.29 | 19.47 |
| <i>Symplocos theifolia</i> D. Don. | Kharanay | 94.737 | 65.277 | 177.26 | 0.169 | 16.848 | 13.16 | 120.34 |
| <i>Symplocos glomerata</i> King ex C.B. Clarke | Kholme | 13.158 | 27.414 | 17.82 | 0.211 | 3.717 | 18.42 | 52.18 |
| <i>Tetradium fraxinifolium</i> (Hook. f.) T.G. Hartley | Khanakpa | 2.632 | 16.222 | 13.08 | 0.380 | 1.150 | 23.68 | 42.105 |
| <i>Yushania maling</i> (Gamble) R.B. Majumdar & Karthik | Malingo (no of clumps) | 360.526 | 190.960 | | 0.362 | 40.281 | | |

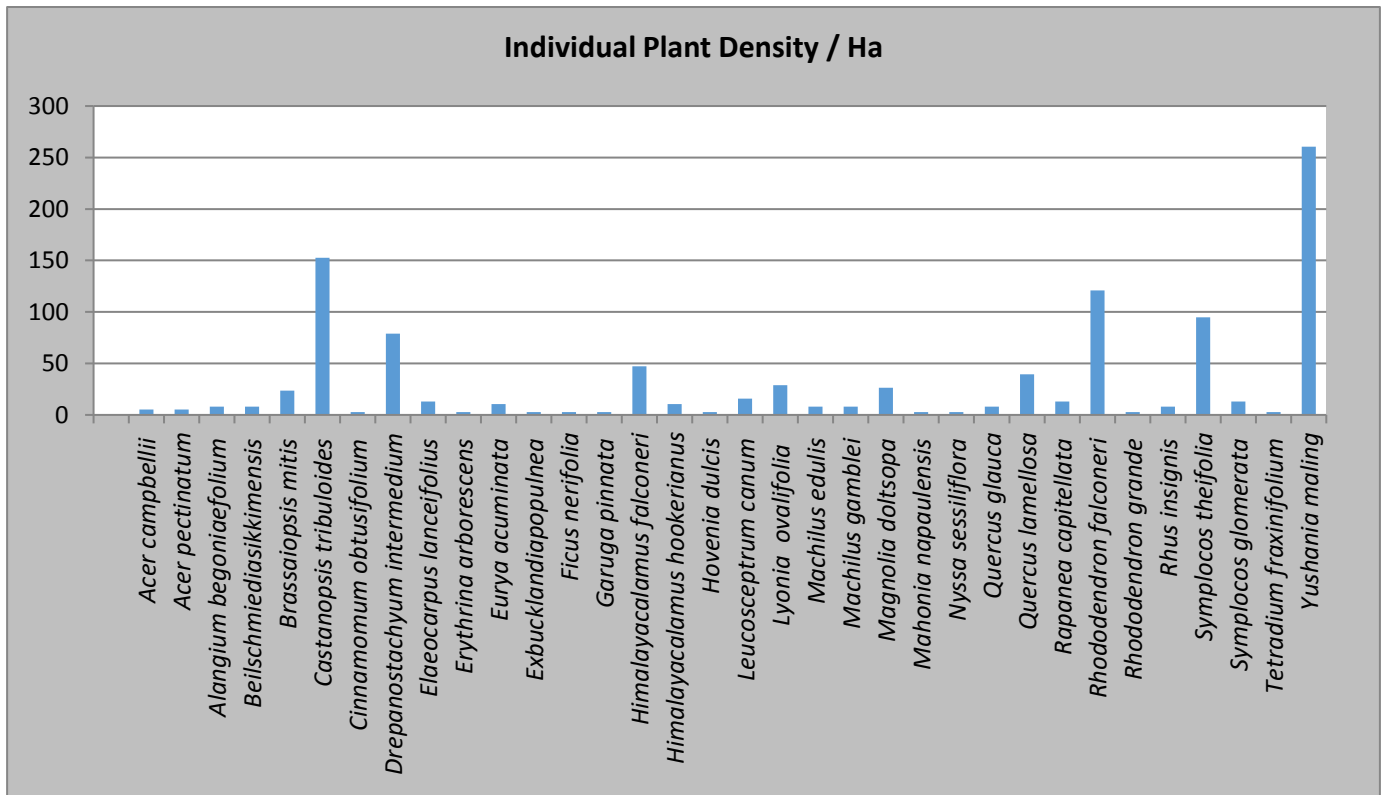


Figure 11: Availability and distribution of trees and bamboos species in Barapathing RF, East Sikkim

| Parameters | Trees | Saplings | Seedlings |
|--------------------------------|-------|----------|-----------|
| Diversity Index (H) | 2.45 | 1.63 | 1.53 |
| Concentration of Dominance (D) | 0.04 | - | - |
| Species Richness Index (I) | 33.83 | 5.68 | 8.79 |
| Species Evenness Index (E) | 0.69 | 0.91 | 0.70 |

Ground Flora

The shrubs and shrublets recorded from the sample plots are *Viburnum erubescens*, *Maesa chisia*, *Edgeworthia gardenerii*, *Dichroa febrifuga*, *Oxyspora paniculata*, *Osbeckia stellata*,

Daphne papyracea, *Rubus* sp., *Rubus ellipticus*, *Antidesma acuminatum* and *Gaultheria nummularioides*. The availability and distribution of shrubs and shrublets in terms of average percent cover and percent frequency are represented in **Table 13**. Likewise, the availability and distribution of bamboo/cane and herbs species are represented in **Tables 14 & 15**, respectively. Diversity of the ground covering herbs species in the area recorded high (**Table 15**), but in terms of density, in percent cover and percent frequency was comparatively less in the area, which may be because of the high canopy cover inside the forest.

Table 13: Availability and distribution of shrubs and shrublets in Barapathing RF, East Sikkim

| Botanical name | Local name | % Frequency | % Cover |
|----------------------------------|--------------|-------------|---------|
| <i>Antidesma acuminatum</i> | Lek bilauney | 5.26 | 1.05 |
| <i>Daphne papyracea</i> | Kalo argeli | 7.89 | 0.92 |
| <i>Dichroa febrifuga</i> | Basak | 13.16 | 0.92 |
| <i>Edgeworthia gardenerii</i> | Argali | 2.63 | 0.13 |
| <i>Gaultheria nummularioides</i> | Kali gedi | 2.63 | 0.53 |
| <i>Maesa chisia</i> | Bilauney | 5.26 | 0.26 |
| <i>Osbeckia stellata</i> | Chulesi | 2.63 | 0.13 |
| <i>Oxyspora paniculata</i> | Oxysp | 7.89 | 0.92 |
| <i>Rubus ellipticus</i> | Aiselu | 7.89 | 1.32 |
| <i>Rubus sp.</i> | Fir firay | 7.89 | 1.84 |
| <i>Viburnum erubescens</i> | Asare | 5.26 | 0.66 |

Table 14: Availability and distribution of bamboo and cane species in Barapathing RF, East Sikkim

| Botanical name | Local name | % Frequency | % Cover |
|------------------------------------|----------------|-------------|---------|
| <i>Drepanostachyum intermedium</i> | Nigalo | 2.63 | 0.13 |
| <i>Himalayacalamus falconeri</i> | Singanay bans | 5.26 | 0.92 |
| <i>Himalayacalamus hookerianus</i> | Paryang | 5.26 | 0.66 |
| <i>Plectocomia himalayana</i> | Beth (Fyakray) | 5.26 | 0.26 |
| <i>Yushania maling</i> | Malingo | 26.32 | 12.89 |

RE-GENERATION STATUS / FOREST HEALTH STATUS

Forest re-generation status or forest health status was analysed on the basis of tree diameter class, wherein, the girth of the adult trees falling in diameter class 30-60cm found to be highest in density, followed by seedlings and saplings (**Figure 12**). The high availability of the seedlings, saplings and adult trees of DBH class above 121 cm in the forest shows that the status of the forest is stable. Likewise, the diameter class distribution for some of the dominant trees in the area has been represented in **Plates V & VI**.

The availability of the saplings of existing large trees species of the area was recorded very less for some species namely *Elaeocarpus lanceifolius*, *Machilus edulis*, *Acer campbellii*, *Brassiopsis mitis*, *Quercus lamellosa* and *Hovenia dulcis* and to nil for some species

namely *Acer pectinatum*, *Alangium begoniaefolium*, *Beilschmiedia sikkimensis*, *Castanopsis tribuloides*, *Cinnamomum impressinervium*, *Exbucklandia populnea*, *Ficus neriifolia*, *Garuga pinnata*, *Machilus edulis*, *Magnolia doltsopa*, *Nyssa sessiliflora*, *Quercus glauca* and *Rapanea capitellata*. The highest sapling density was recorded for small trees and shrubs namely *Rhododendron falconeri* and *Leucocephalum cannum* followed by *Eurya acuminata*, *Pieris ovalifolia*, *Tetradium fraxinifolium*, etc. (**Figure 13**).

Table 15: Availability and distribution of herb species in Barapathing RF, East Sikkim

| Sl. No | Botanical name | Local name | % Frequency | % Cover |
|--------|----------------------------------|------------------|-------------|---------|
| 1 | <i>Aconogonum campanulatum</i> | Kukur dainey | 13.16 | 0.92 |
| 2 | <i>Aconogonum molle</i> | Thotnay | 10.53 | 1.18 |
| 3 | <i>Acorus calamus</i> | Bojo | 2.63 | 1.05 |
| 4 | <i>Aeschynanthus parviflorus</i> | Baklaypatay | 10.53 | 0.61 |
| 5 | <i>Aeschynanthus hookeri</i> | Baklay patay | 10.53 | 1.00 |
| 6 | <i>Ampelocissus latifolia</i> | Pani lahara | 2.63 | 0.39 |
| 7 | <i>Anaphalis triplinervis</i> | BukeyPhool | 7.89 | 0.79 |
| 8 | <i>Arisaema intermedium</i> | Larua/Banko | 2.63 | 0.26 |
| 9 | <i>Arisaema flavum</i> | Sap ko makai | 2.63 | 0.13 |
| 10 | <i>Arisaema speciosum</i> | Sap ko Makai | 2.63 | 0.13 |
| 11 | <i>Artemisia vulgaris</i> | Titaypati | 7.89 | 0.34 |
| 12 | <i>Begonia picta</i> | Magar kanje | 7.89 | 1.05 |
| 13 | <i>Boehmeria platyphylla</i> | Kamley | 5.26 | 0.21 |
| 14 | <i>Campylandra aurantiaca</i> | Jangali nakima | 5.26 | 1.32 |
| 15 | <i>Carex sp.</i> | Harkatto | 7.89 | 0.61 |
| 16 | <i>Cautleya spicata</i> | Sara | 7.89 | 0.53 |
| 17 | <i>Coelogyne flaccida</i> | Sunakhari | 10.53 | 0.66 |
| 18 | <i>Commelina benghalensis</i> | Kanay | 2.63 | 0.26 |
| 19 | <i>Cyanotis vaga</i> | Kanay | 5.26 | 0.26 |
| 20 | <i>Cynodon dactylon</i> | Dubo | 5.26 | 1.32 |
| 21 | <i>Dendrobium densiflorum</i> | Ghogay sunakhari | 2.63 | 0.26 |
| 22 | <i>Digitaria sanguinalis</i> | Banso | 5.26 | 0.53 |
| 23 | <i>Elatostema platyphyllum</i> | Gagleto | 5.26 | 0.26 |
| 24 | <i>Elatostema sessile</i> | Gagleto | 5.26 | 0.26 |
| 25 | <i>Eupatorium adenophorum</i> | Kali jhar | 7.89 | 0.81 |
| 26 | <i>Fragaria nubicola</i> | Bhui-aiselu | 5.26 | 0.26 |
| 27 | <i>Gerardiana diversifolia</i> | Bhangre sisnu | 7.89 | 0.69 |
| 28 | <i>Hedychium spicatum</i> | Gai sara | 5.26 | 0.79 |
| 29 | <i>Hemiphragma heterophyllum</i> | Nash jhar | 5.26 | 0.79 |
| 30 | <i>Impatiens stenantha</i> | Mujuro | 5.26 | 0.39 |
| 31 | <i>Impatiens urticifolia</i> | Mujuro | 7.89 | 0.79 |
| 32 | <i>Mucuna macrocarpa</i> | Baldengro | 2.63 | 0.13 |
| 33 | <i>Lecanthus peduncularis</i> | Gagleto | 7.89 | 1.45 |
| 34 | <i>Piper sp.</i> | Chabo | 5.26 | 0.26 |
| 35 | <i>Persicaria capitata</i> | Ratnaulo | 13.16 | 1.18 |

| | | | | |
|----|-----------------------------------|------------------------------|-------|------|
| 36 | <i>Pleione praecox</i> | | 5.26 | 0.39 |
| 37 | <i>Rhapidiphora decursiva</i> | Kanchirnu | 5.26 | 0.26 |
| 38 | <i>Rubia cordifolia</i> | Majito | 10.53 | 0.92 |
| 39 | <i>Schizandra neglecta</i> | Singatthey lahara | 2.63 | 0.13 |
| 40 | <i>Rumex nepalensis</i> | Halhalley | 5.26 | 0.39 |
| 41 | <i>Selaginella biformis</i> | Jhew | 10.53 | 1.05 |
| 42 | <i>Selaginella chrysocaulos</i> | Jhew | 15.79 | 1.97 |
| 43 | <i>Solanum sp.</i> | | 15.79 | 1.03 |
| 44 | <i>Selaginella monospora</i> | Jhew | 7.89 | 0.92 |
| 45 | <i>Smilax sp.</i> | Madaneykara / Kirneyghans | 2.63 | 0.53 |
| 46 | <i>Strobilanthes sp.</i> | Kibug hans | 10.53 | 0.92 |
| 47 | <i>Swertia bimaculata</i> | Bhaley chiraito | 15.79 | 1.97 |
| 48 | <i>Swertia chirayita</i> | Chiraito | 13.16 | 1.97 |
| 49 | <i>Urtica dioica</i> | Patley sisnu | 7.89 | 0.53 |
| 50 | <i>Hedychium sp.</i> | Qiura | 5.26 | 0.26 |
| 51 | <i>Digitaria ciliaris</i> | Chitray Banso | 5.26 | 0.26 |
| 52 | <i>Holboellia angustifolia</i> | Gulfa | 2.63 | 0.54 |
| 53 | <i>Stephania glabra</i> | Tambarkay | 5.26 | 0.39 |
| 54 | <i>Asplenium laciniatum</i> | Uniu | 2.63 | 0.26 |
| 55 | <i>Blechnum orientale</i> | Deer Fern | 2.63 | 0.53 |
| 56 | <i>Coniogramme intermedia</i> | Uniu | 2.63 | 0.26 |
| 57 | <i>Cyathea spinulosa</i> | Rukh uniu | 2.63 | 0.26 |
| 58 | <i>Dennstaedtia appendiculata</i> | Piray uniu | 10.53 | 0.79 |
| 59 | <i>Diplazium dilatatum</i> | Lek Chipley Ningro | 5.26 | 0.53 |
| 60 | <i>Diplazium esculentum</i> | Chiplay ningro | 5.26 | 0.26 |
| 61 | <i>Diplazium stoliczkae</i> | LekKalo Ningro | 5.26 | 0.39 |
| 62 | <i>Equisetum diffusum</i> | Sallibi salli | 7.89 | 0.53 |
| 63 | <i>Gleichenia gigantean</i> | KalamayUniu | 5.26 | 0.39 |
| 64 | <i>Leucostegia truncata</i> | Deer fern | 5.26 | 0.79 |
| 65 | <i>Lycopodium japonicum</i> | Nagbelli | 10.53 | 0.53 |
| 66 | <i>Microsorium membranaceum</i> | Uniu | 5.26 | 0.53 |
| 67 | <i>Nephrolepis cordifolia</i> | Pani amala | 2.63 | 0.26 |
| 68 | <i>Odontosoria chinensis</i> | Uneu | 2.63 | 0.26 |
| 69 | <i>Plagiogyria pycnophylla</i> | Uniu | 13.16 | 0.92 |
| 70 | <i>Pseudodrynaria coronans</i> | Kamray lahara | 2.63 | 0.13 |
| 71 | <i>Pteris wallichiana</i> | Uneu | 5.26 | 0.39 |
| 72 | <i>Xanthium strumarium</i> | Bhedekuro | 2.63 | 0.26 |

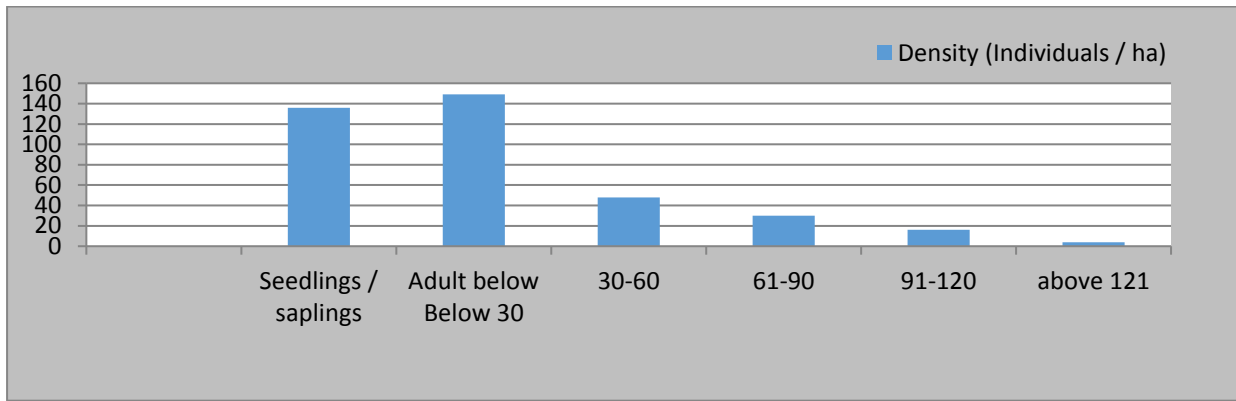


Figure 12: DBH class wise availability (in cm) of the available trees at Barapathing RF

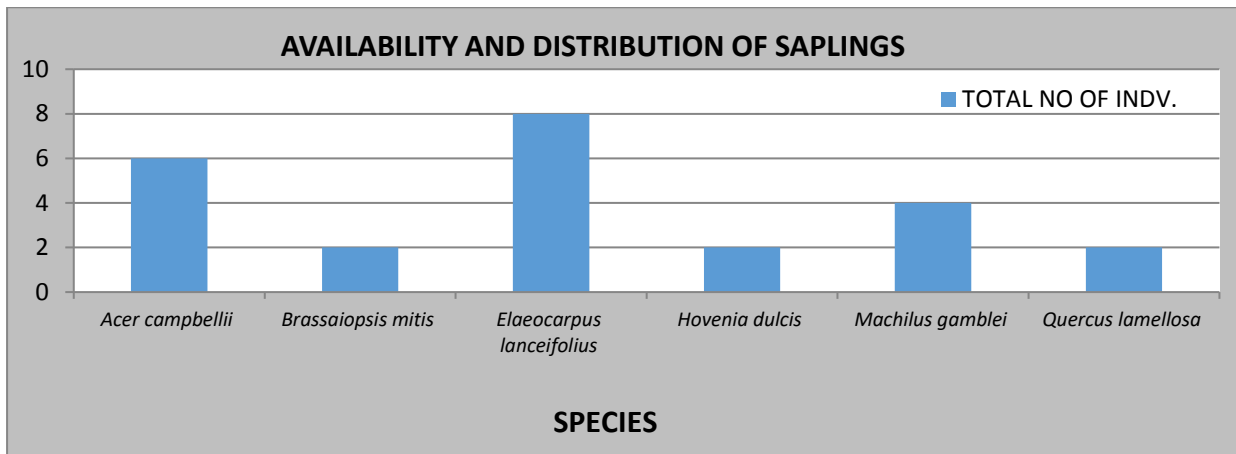


Figure 13: Availability and distribution of saplings in the sampled plots

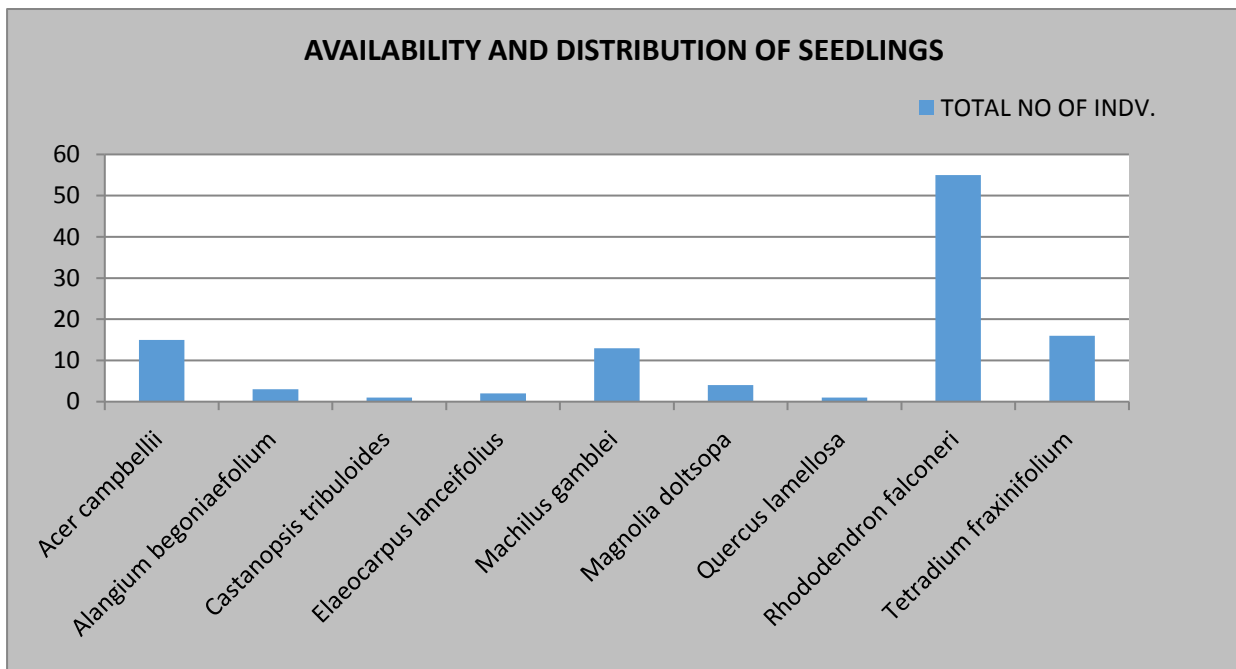


Figure 14: Availability and distribution of seedlings in the sampled plots

In the case of seedlings, the highest density was recorded for *Rhododendron falconeri* and *Symplocos theifolia* followed by *Eurya acuminata*, *Leucocephalum canum*, *Tertadium fraxinifolium*, etc. The seedlings of some of the existing large tree species was recorded with very less number of populations such as *Castanopsis tribuloides*, *Quercus lamellosa* and *Elaeocarpus lanceifolius*. For species such as *Beilschmiedia sikkimensis*, *Brassaiopsis mitis*, *Cinnamomum impressinervium*, *Erythrina arborescens*, *Ficus neriifolia*, *Hovenia dulcis*, *Machilus edulis*, *Nyssa sessiliflora*, *Quercus glauca*, *Rhododendron grande* no any seedlings were recorded in the sampled plots (**Figure 14**).

However, the availability of seedlings, saplings, and small girth class trees of oak species was very less to almost nil in the forest; the diameter class distribution of existing oak species in the area has been represented in **Plate VII**.

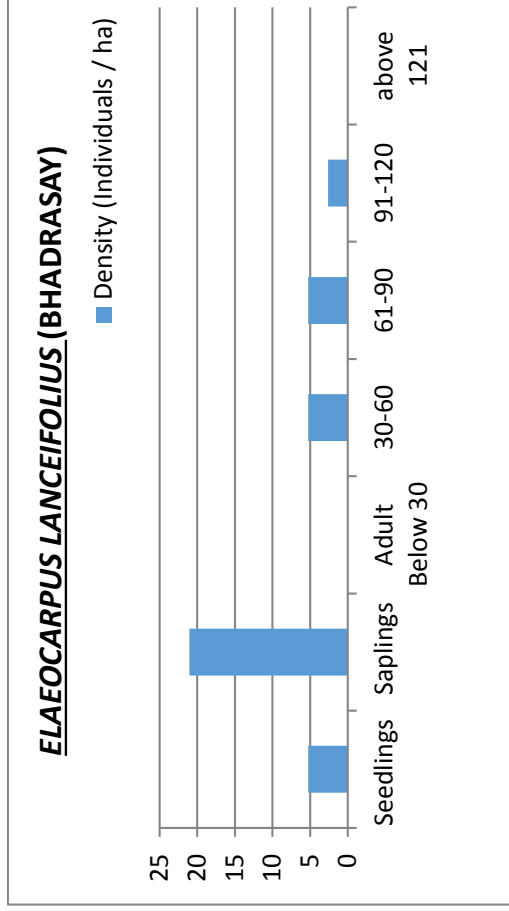
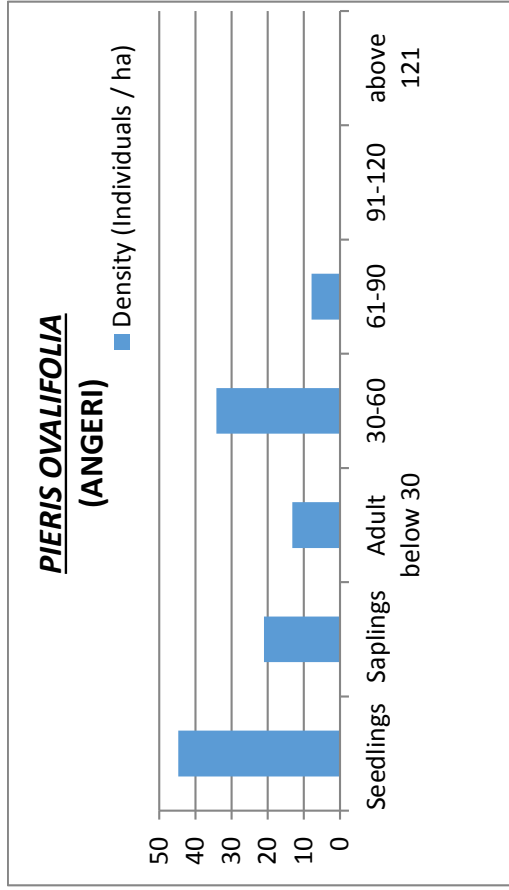
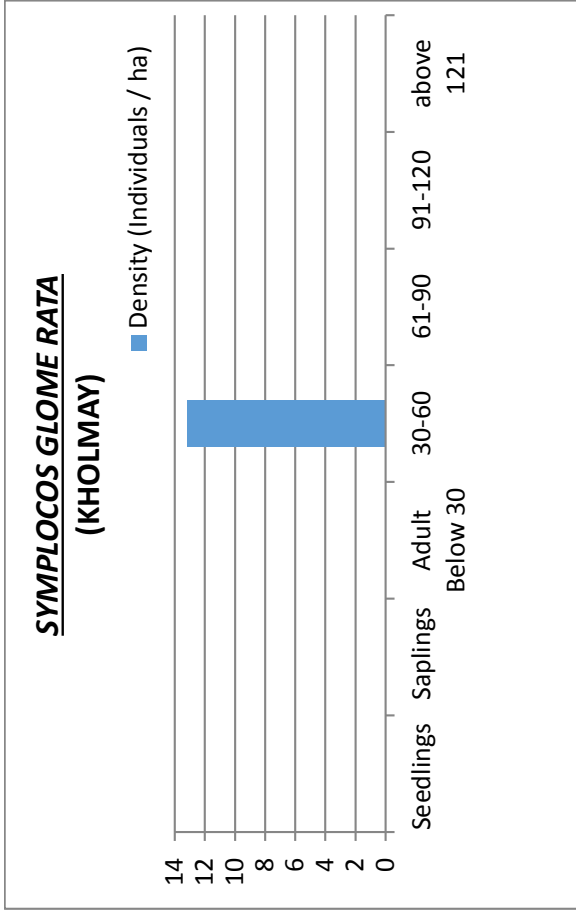
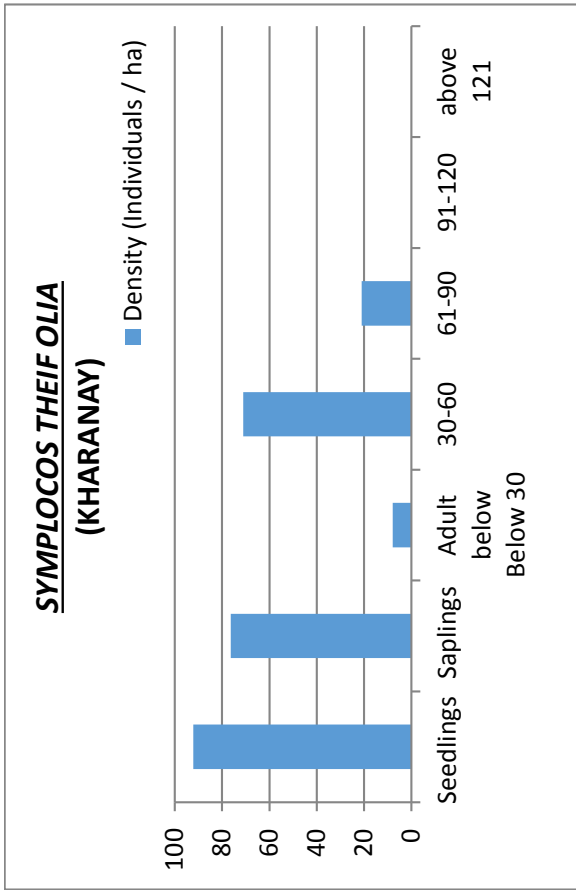


Plate V: Class wise availability (DBH class in cm) of some dominating species at Barapathing Reserve Forest

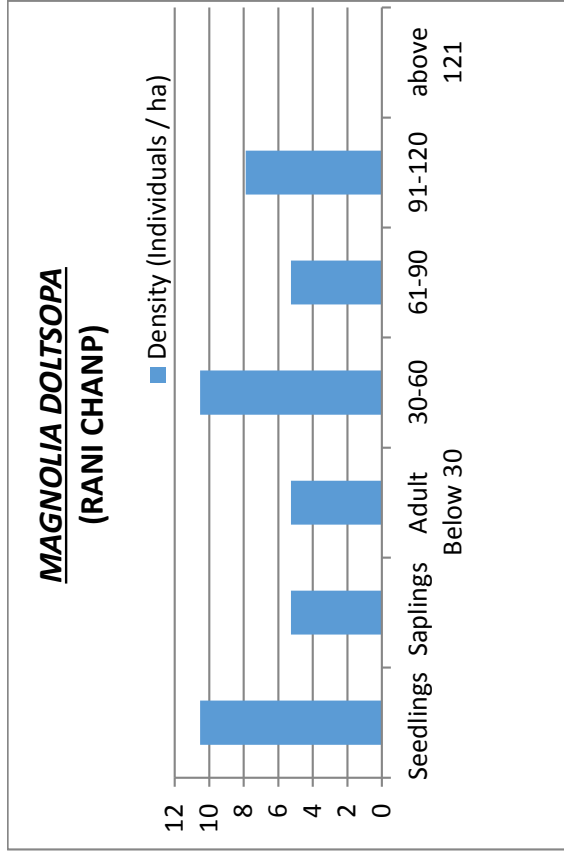
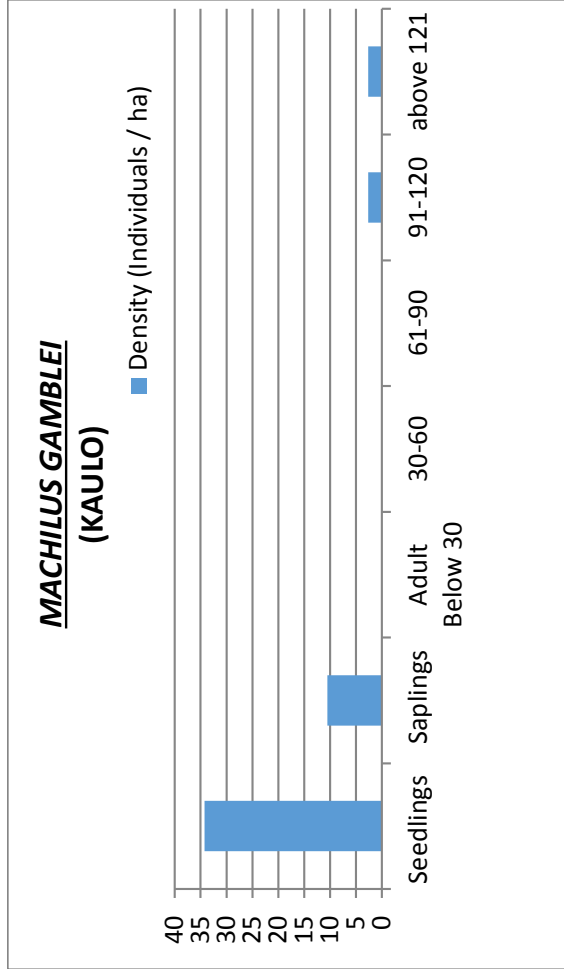
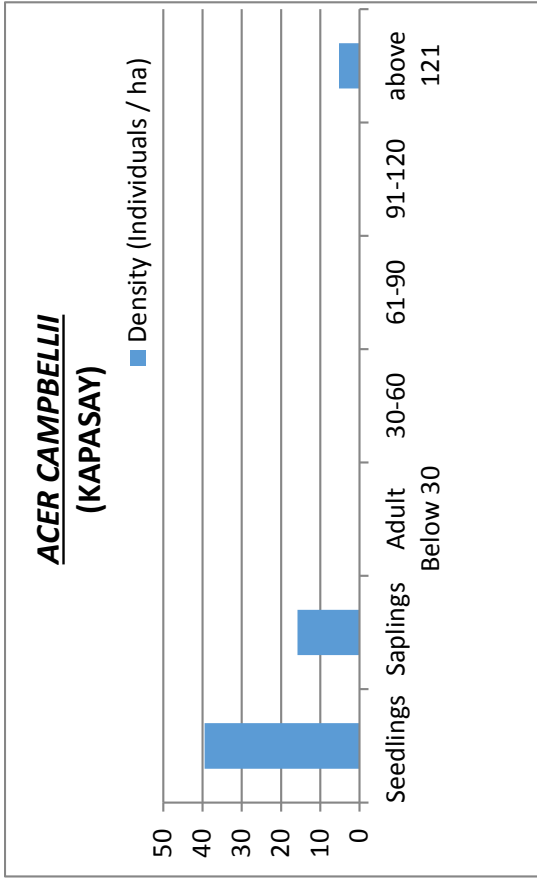
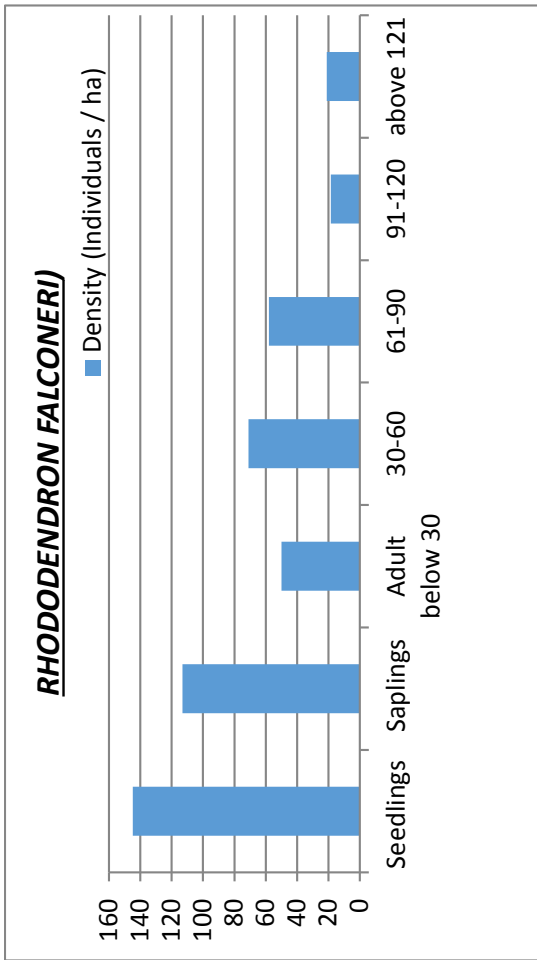
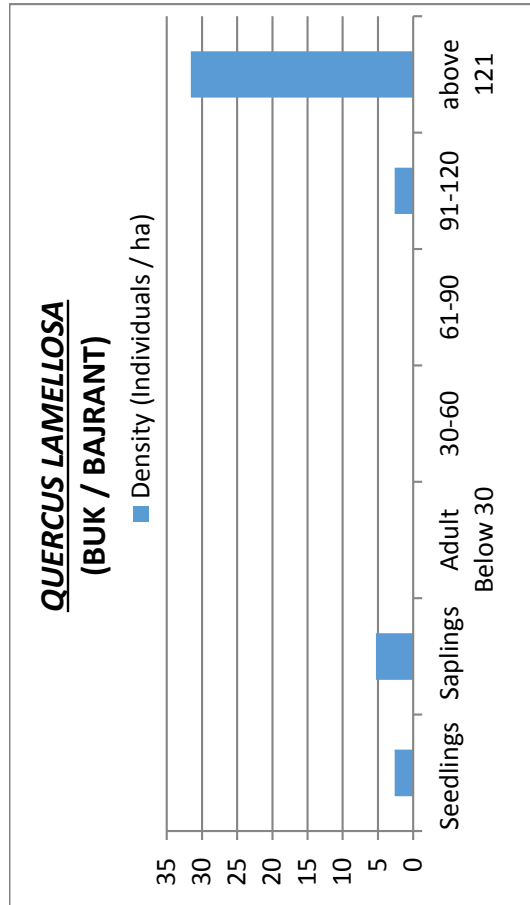
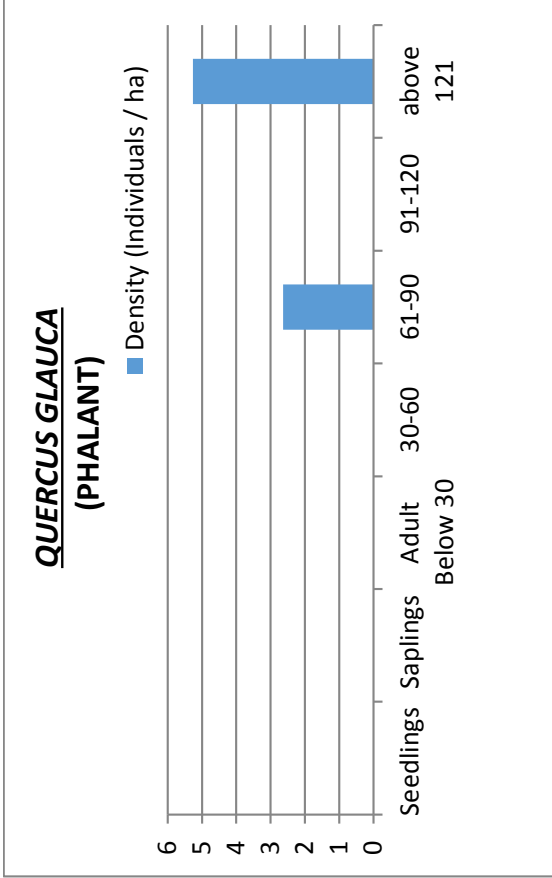
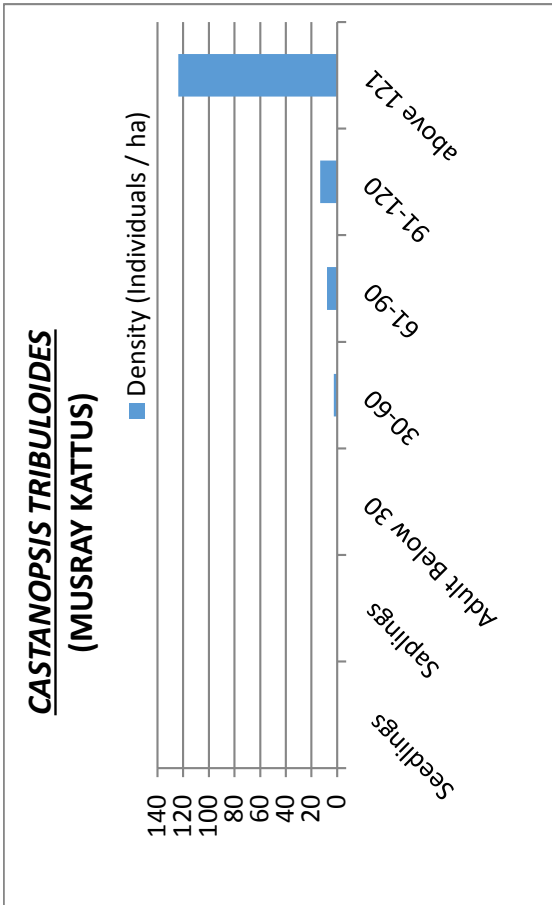


Plate VI: Class wise availability (DBH class in cm) of some dominating species at Barapathing Reserve Forest



For *Quercus pachyphylla* (Sunguray Katus / Oitay / Bantay), *Castanopsis hystrix* (Patle Katus), *Castanopsis indica* (Dhalne Katus) no any seedlings, saplings and adult individual were recorded inside the sample plots.

Plate VII: Class wise availability (DBH class in cm) of oak species at Barapathing Reserve Forest

Fauna

During the biodiversity survey in Barapathing Reserve forest, the existence of a total of 14 mammalian species, 52 bird species and 62 butterfly' species were recorded through direct sightings and indirect evidences, which are listed in **Table 16**.

| Table 16: Checklist of Faunal species, including Mammals, Avi-fauna and butterflies of Barapathing RF and surrounding area in East Sikkim | | | |
|--|----------------------------------|---------------------------------|---------------|
| Sl.No | Common name | Scientific name | Family |
| Mamalian Species | | | |
| 1 | Jackel | <i>Cannis aurens</i> | Canidae |
| 2 | Himalayan Serow | <i>Capricornis thar</i> | Bovidae |
| 3 | Parti-colored flying squirrel | <i>Hylopetes alboniger</i> | Sciuridae |
| 4 | Kalij pheasant | <i>Lophura leucomelana</i> | Phasianidae |
| 5 | Yellow-Throated marten | <i>Martes flavigula</i> | Mustelids |
| 6 | Barking Deer | <i>Muntiacus muntjak</i> | Cervidae |
| 7 | Goral | <i>Naemorhedus goral</i> | Bovidae |
| 8 | Himalayan palm civet | <i>Paguma larvata</i> | Viverridae |
| 9 | Wild pig | <i>Sus scrofa</i> | Suidae |
| 10 | Satyr tragopan | <i>Tragopan satyra</i> | Phasianidae |
| 11 | Himalayan black Bear | <i>Ursus thibetanus</i> | Ursidae |
| 12 | Himalayan Crestless Porcupine | <i>Hystrix brachyura</i> | Hystricidae |
| 13 | Hoary Bellied Himalayan Squirrel | <i>Callosciurus pygarythrus</i> | Sciuridae |
| 14 | Himalayan Thar | <i>Hemitragus jemlahicus</i> | Bovidae |
| Avi – Fauna Species | | | |
| 1 | Ashy Drongo | <i>Dicrurus leucophaeus</i> | Dicruridae |
| 2 | Barred Cuckoo Dove | <i>Macropygia unchall</i> | Columbidae |
| 3 | Blue Whistling Thrush | <i>Myophonus caeruleus</i> | Turdidae |
| 4 | Blue-fronted Redstart | <i>Phoenicurus frontalis</i> | Muscicapidae |
| 5 | Blue-winged Siva | <i>Siva cyanouroptera</i> | Timaliidae |
| 6 | Black bulbul | <i>Hypsipetes leucocephalus</i> | Pycnonotidae |
| 7 | Common Green Magpie | <i>Cissa chinensis</i> | Corvidae |
| 8 | Common Hoopoe | <i>Upupa epops</i> | Upupidae |
| 9 | Common Myna | <i>Acridotheres tristis</i> | Sturnidae |
| 10 | Common pigeon | <i>Columba libia</i> | Columbidae |
| 11 | Common Tailored Bird | <i>Orthotomus sutorius</i> | Cisticolidae |
| 12 | Golden-breasted Fulvetta | <i>Lioparus chrysotis</i> | Sylviidae |
| 13 | Great Barbet | <i>Megalaima virens</i> | Ramphastidae |
| 14 | Greater Yellownappe | <i>Picus flavinucha</i> | Picidae |
| 15 | Green-backed Tit | <i>Parus monticolus</i> | Paridae |

| | | | |
|--------------------------|---------------------------------|------------------------------------|----------------|
| 16 | Green-tailed Sunbird | <i>Aethopyga nipalensis</i> | Nectariniidae |
| 17 | Grey-backed Shrike | <i>Lanius tephronotus</i> | Laniidae |
| 18 | Grey-headed Canary Flycatcher | <i>Culicicapa ceylonensis</i> | Stenostiridae |
| 19 | Grey-headed Parakeet | <i>Psittacula finschii</i> | Psittacidae |
| 20 | Himalayan Bluetail | <i>Tarsiger rufilatus</i> | Muscicapidae |
| 21 | Himalayan Bulbul | <i>Pycnonotus leucogenys</i> | Pycnonotidae |
| 22 | Hodgson's Redstart | <i>Phoenicurus hodgsoni</i> | Muscicapidae |
| 23 | House Crow | <i>Corvus splendens</i> | Corvidae |
| 24 | House Sparrow | <i>Passer domesticus</i> | Passeridae |
| 25 | Kalij Pheasant | <i>Lophura leucomelanos</i> | Phasianidae |
| 26 | Large-billed Crow | <i>Corvus macrorhynchos</i> | Corvidae |
| 27 | Lesser Yellownape | <i>Picus chlorolophus</i> | Picidae |
| 28 | Little Spiderhunter | <i>Aracanothra longirostra</i> | Nectariniidae |
| 29 | Nepal Fulvetta | <i>Alcippe nipalensis</i> | Sylviidae |
| 30 | Oriental Magpie Robin | <i>Copsychus saularis</i> | Muscicapidae |
| 31 | Oriental Turtle Dove | <i>Streptopelia orientalis</i> | Columbidae |
| 32 | Oriental White-eye | <i>Zosterops palpebrosus</i> | Zosteropidae |
| 33 | Red-billed Leiothrix | <i>Leiothrix lutea</i> | Timaliidae |
| 34 | Red-tailed Minla | <i>Minla ignotincta</i> | Leiothrichidae |
| 35 | Red-vented Bulbul | <i>Pycnonotus cafer</i> | Pycnonotidae |
| 36 | Rufous sibia | <i>Malacias capistratus</i> | Timaliidae |
| 37 | Rufous-bellied Niltava | <i>Niltava sundara</i> | Muscicapidae |
| 38 | Rufous-gorgeted Flycatcher | <i>Ficedula strophiat</i> | Muscicapidae |
| 39 | Scaly Laughingthrush | <i>Garrulax austeni</i> | Turdidae |
| 40 | Scarlet Minivet | <i>Pericrocotus cinnamomeus</i> | Campephagidae |
| 41 | Silver-eared Mesia | <i>Mesia argentauris</i> | Leiothrichidae |
| 42 | Slender-billed Scimitar Babbler | <i>Xiphirhynchus superciliaris</i> | Timaliidae |
| 43 | Spangled Drongo | <i>Dicrurus hottentottus</i> | Dicruridae |
| 44 | Stripe-throated Yuhina | <i>Yuhina gularis</i> | Zosteropidae |
| 45 | Velvet-fronted Nuthatch | <i>Sitta frontalis</i> | Sittidae |
| 46 | Verditer flycatcher | <i>Eumyias thalassinus</i> | Muscicapidae |
| 47 | Whiskered Yuhina | <i>Yuhina flavicollis</i> | Zosteropidae |
| 48 | White-browed Fulvetta | <i>Fulvetta vinipectus</i> | Sylviidae |
| 49 | White-browed Piculat | <i>Sasia ochracea</i> | Picidae |
| 50 | White-capped Redstart | <i>Chaimarrornis leucocephalus</i> | Muscicapidae |
| 51 | White-crested Laughingthrush | <i>Garrulax leucolophus</i> | Turdidae |
| 52 | Yellow-bellied Fantail | <i>Chelidorhynch hypoxantha</i> | Rhipiduridae |
| Butterfly species | | | |
| 1 | Autumn leaf | <i>Doleschallia bisaltidae</i> | Nymphalidae |
| 2 | Banded Treebrown | <i>Lethe confuse</i> | Nymphalidae |
| 3 | Blue Peacock | <i>Papilio acturus</i> | Papilionidae |

| | | | |
|----|----------------------|--------------------------------|--------------|
| 4 | Chocolate Pansy | <i>Junonia iphita</i> | Nymphalidae |
| 5 | Common Bushbrown | <i>Mycalesis perseus</i> | Nymphalidae |
| 6 | Common cerculean | <i>Jamides celeno</i> | Lycaenidae |
| 7 | Common Crow | <i>Euploea core</i> | Nymphalidae |
| 8 | Common Earl | <i>Tanaecia julii</i> | Nymphalidae |
| 9 | Common Evening Brown | <i>Melanitis leda</i> | Nymphalidae |
| 10 | Common Five Ring | <i>Ypthima baldus</i> | Nymphalidae |
| 11 | Common Grass Yellow | <i>Eurema hecabe</i> | Pieridae |
| 12 | Common Jester | <i>Symbrenthia hippoclus</i> | Nymphalidae |
| 13 | Common Line Blue | <i>Posotas nora</i> | Lycaenidae |
| 14 | Common Map | <i>Cyrestis thyodamas</i> | Nymphalidae |
| 15 | Common Maplet | <i>Chersonesia risa</i> | Nymphalidae |
| 16 | Common Mormon | <i>Papilio polytes</i> | Papilionidae |
| 17 | Common Nawab | <i>Polyuria athamas</i> | Nymphalidae |
| 18 | Common Palmfly | <i>Elymnias hypermnestra</i> | Nymphalidae |
| 19 | Common Peacock | <i>Papilio polyctor</i> | Papilionidae |
| 20 | Common Pierrot | <i>Castalius rosimon</i> | Lycaenidae |
| 21 | Common Red Eye | <i>Matapa aria</i> | Hesperiidae |
| 22 | Common Red Forester | <i>Lethe mekara</i> | Nymphalidae |
| 23 | Common Sergeant | <i>Athyma perius</i> | Nymphalidae |
| 24 | Common Silverline | <i>Spindasis vulcans</i> | Lycaenidae |
| 25 | Common Small Flat | <i>Sarangesa dasahara</i> | Hesperiidae |
| 26 | Common Windmill | <i>Atrophaneura polyeuctes</i> | Papilionidae |
| 27 | Dark Judy | <i>Abisara fylla</i> | Riodinidae |
| 28 | Fluffy tit | <i>Zeltus amasa</i> | Lycaenidae |
| 29 | Fulvous pied Flat | <i>Pseudocoladenia dan</i> | Hesperiidae |
| 30 | Glassy Bluebottle | <i>Graphium sarpedon</i> | Papilionidae |
| 31 | Golden Sapphire | <i>Heliophorus brahma</i> | Lycaenidae |
| 32 | Grass Demon | <i>Udaspes folus</i> | Hesperiidae |
| 33 | Green Commodore | <i>Sumalia daraxa</i> | Nymphalidae |
| 34 | Indian Cabbage White | <i>Pieris canidia</i> | Pieridae |
| 35 | Indian Fritillary | <i>Argynnis hyperbius</i> | Nymphalidae |
| 36 | Indian Red Admiral | <i>Venessa indica</i> | Nymphalidae |
| 37 | Indian Skipper | <i>Spialian galba</i> | Hesperiidae |
| 38 | Indian Tortoiseshell | <i>Aglais cashmiriensis</i> | Nymphalidae |
| 39 | Large Yeoman | <i>Cirrochroa aoris</i> | Nymphalidae |
| 40 | Lemon Pansy | <i>Junonia lemonias</i> | Nymphalidae |
| 41 | Mixed Punch | <i>Dodona ouida</i> | Riodinidae |
| 42 | Nigger | <i>Orsotrioena medus</i> | Nymphalidae |
| 43 | Orange Oakleaf | <i>Kallima inachus</i> | Nymphalidae |
| 44 | Orange Punch | <i>Dodona egeon</i> | Riodinidae |

| | | | |
|----|-------------------|--------------------------------|--------------|
| 45 | Painted Lady | <i>Venessa cardui</i> | Nymphalidae |
| 46 | Plain Tiger | <i>Danaus chrysippus</i> | Nymphalidae |
| 47 | Punchinello | <i>Zemeros flegyas</i> | Riodinidae |
| 48 | Purple Sapphire | <i>Heliophorus epicles</i> | Lycaenidae |
| 49 | Red Helen | <i>Papilio helenus</i> | Papilionidae |
| 50 | Red Lacewing | <i>Cethosia biblustinamena</i> | Nymphalidae |
| 51 | Redbreast | <i>Papilio alcmenor</i> | Papilionidae |
| 52 | Rice Swift | <i>Borbo cinnara</i> | Hesperiidae |
| 53 | Spotted sawtooth | <i>Prioneris thestylis</i> | Pieridae |
| 54 | Spotted Snow Flat | <i>Tagiades menaka</i> | Hesperiidae |
| 55 | Striped Tiger | <i>Danaus genutia</i> | Nymphalidae |
| 56 | Tailed Jay | <i>Graphium agamemnon</i> | Papilionidae |
| 57 | Tailed Judy | <i>Abisara fylla</i> | Riodinidae |
| 58 | Tiger Hooper | <i>Ochus subvittatus</i> | Hesperiidae |
| 59 | Water Snow Flat | <i>Tagiades litigiosa</i> | Hesperiidae |
| 60 | Yam fly | <i>Loxura atymnus</i> | Lycaenidae |
| 61 | Yellow Helen | <i>Papilio nephelus</i> | Papilionidae |
| 62 | Yellow Orange Tip | <i>Ixias pyrene</i> | Peiridae |

CONCLUSION AND RECOMMENDATION

Till date Barapathing reserve forest remain unexplored which, during the present study, found to be rich in terms of the diversity of the species. The biodiversity of the area remain undisturb or intact to some extent till date. The unsustainable extraction of plants especially for firewood and livestock feed by the local inhabitants, grazing (with low intensity) are the general disturbances resulted in the building up considerable pressure on the survival of the species. The re-generation status of oak forest and other highly dense forest has been observed / analysed very poor, for which cultural thinning of the forest as well as massive plantation can be recommended. Studies on the impact of climate change on the biodiversity is recommended, which will be helpful in framing conservation and management strategies.



Photo 6: *Rhododendron falconeri*

Quantitative Analysis of Vegetation and Assessment of Faunal Diversity of Darap Reserve Forest in West Sikkim, India

*Sanjyoti Subba, Sanchi Subba and Sumitra Nepal

ABSTRACT

The present study was carried out in subtropical forest to wet temperate forest of Darap Reserve Forest in West Sikkim. A total of 114 plant species belonging to 96 genera and 60 families were recorded from the 15 sampling plots covering an area of 0.15 ha, out of which 37 trees, 15 shrubs, 42 herbs, 11 climbers and epiphytes, and 9 ferns and fern-allies were recorded. Additionally, the area also harbours over 12 orchid species. Diversity of vegetation was found most in case of the ground flora in comparison to the trees and shrubs. The highest adult individuals were recorded for *Cryptomeria japonica* (180.00 Ind/ha) followed by *Symplocos lucida* (186.67Ind/ha), *Symplocos glomerata* (173.33Ind/ha), *Castanopsis indica* (60.00Ind/ha) and *Castanopsis tribuloides* (60.00Ind/ha). Regarding the importance value index of this site, the highest Importance Value Index (IVI) was recorded for *Magnolia velutina* (86.38) followed by *Symplocos lucida* (23.66), *Symplocos glomerata* (22.95), *Cryptomeria japonica* (19.90) and *Castanopsis indica* (11.54). The maximum species richness was recorded for tree (37.813) followed by seedling (13.819) and sapling (12.797). The biodiversity index value was found to be between 2.057 and 3.320. That means the regeneration potential is higher. The higher tree species richness showed an increased forest with decreasing disturbance in the forest. A greater number of species in a community is ecologically important as diversity seems to increase with increasing community stability.

Keywords: Rapid Biodiversity Survey, Darap Reserve Forest, Species Diversity and Richness, Biodiversity Conservation



Pleione praecox

INTRODUCTION

Vegetation in the world is usually formed by one or more plant communities showing homogeneous stands or more often heterogeneous groups (Subba *et al.* 2017). The plant community is identified as components of biological diversity and needs to be identified and monitored. The vegetative community of the area is a function of forests by elevation, slope, precipitation and humidity playing a role in the formation of plant communities and their composition. Within one altitude, the cofactors like topography, aspect, inclination of slope and soil type further affects the forest composition (Holland & Steyn 1975). Plant communities are defined as an assemblage of functionally similar species populations that occur together in time and space (Magurran 1988).

In general, biodiversity measurement tends to focus on species levels, and biodiversity is one of the key indices used to assess ecosystems at various scales (Ardakani 2004). Plant species richness and species diversity is simple and easily interpretable indicator of biological diversity (Peet 1974). However, for temperate forests, Monk (1967) and Risser & Rice (1971) reported 2 – 3 as the highest value for diversity index and the index is rarely greater than 4. For Indian forests, the diversity index ranged between 0.83 and 4.1 (Singh *et al.* 1984; Parthasarthy *et al.* 1992; Visalakshi 1995). The northeast region of India is considered as one of the biodiversity hotspots of the Eastern Himalayan Region. According to Takhtajan (1988), it is the centre of origin of angiosperms. Sikkim, a constituent of Indo-Burma biodiversity hotspot, the vegetation of this region habitats about 5500 species of flowering plants, with more than 450 tree species, 480 species of fern and its allies, 9 tree fern species, 11 oak species, 16 conifer species, 28 bamboo species, 30 primula species and 150 species of wild edible plants forms the floral composition of the State as mentioned in (<http://www.sikkimforest.gov.in/biodiversity.htm>).

Rapid biodiversity survey was carried out in subtropical to wet temperate forest of Darap reserve forest in west Sikkim (1) biodiversity assessment and analysis of vegetation in two different forest types (2) species diversity and dominance which provide current status of forest structure and composition.

STUDY AREA

The study was conducted in Darap reserve forest located in the west district of Sikkim occupying an area of 1.22 km² and sharing its border with Lunggang RF and SingrangpongRF over the Rimbi khola in the Western Sikkim. It is a biologically diverse reserve forest and the climate is monsoonal with warm-moist summer and cold in winter. The survey team covered the sub-tropical forest to wet temperate forest.

The elevation ranges between 1800m to 2200m ASL lying between latitude 27°17'16.7"N to 27°17'59.0"N and longitude 88°11'01.3"E to 88°10'58.8"E along the sampling plot (**Figure 15a & b; Table 17**). The area is having rich diversity of floral species and home to many faunal species such as Himalayan black bear, Wild pig, Barking deer, Flying squirrel, Wild dog, Red fox, etc. As the forest is dense, it provides shelter as well as abundant fruits/feed to animals and as such is good indicator of faunal presence and richness. Human-wildlife conflict is one of the main threats in the forest especially the presence of Himalayan black bear.

DOMINANT TAXA



Photos 7 & 8: *Symplocos glomerata* and *Symplocos lucida*

METHODOLOGY

During 2017, random sampling plots of 10m x 10m were laid, depending upon the site feasibility, covering a total area of 0.15 ha. Within the main plot, all the standing tree species were enumerated and measured (CBH) at 1.37 m from the ground. Circumference at breast height (1.37 m) was taken for the determination of tree basal area. Basal area (m² / ha) was used to determine the relative dominance of a tree species. Within the subplots, 5m x 5m

were laid for recording saplings (no. of species and its height) and shrubs; and for recording the percent cover, the same quadrat was used. For seedlings and herbs enumeration, 1m x 1m was laid in 5 corners. Plant species were identified through herbarium record and flora (Hooker JD 1888-1890; Hooker JD 1849; Pradhan & Lachungpa 1990; Kholia 2010). The unidentified plant species in the field were photographed, and later identified by consulting

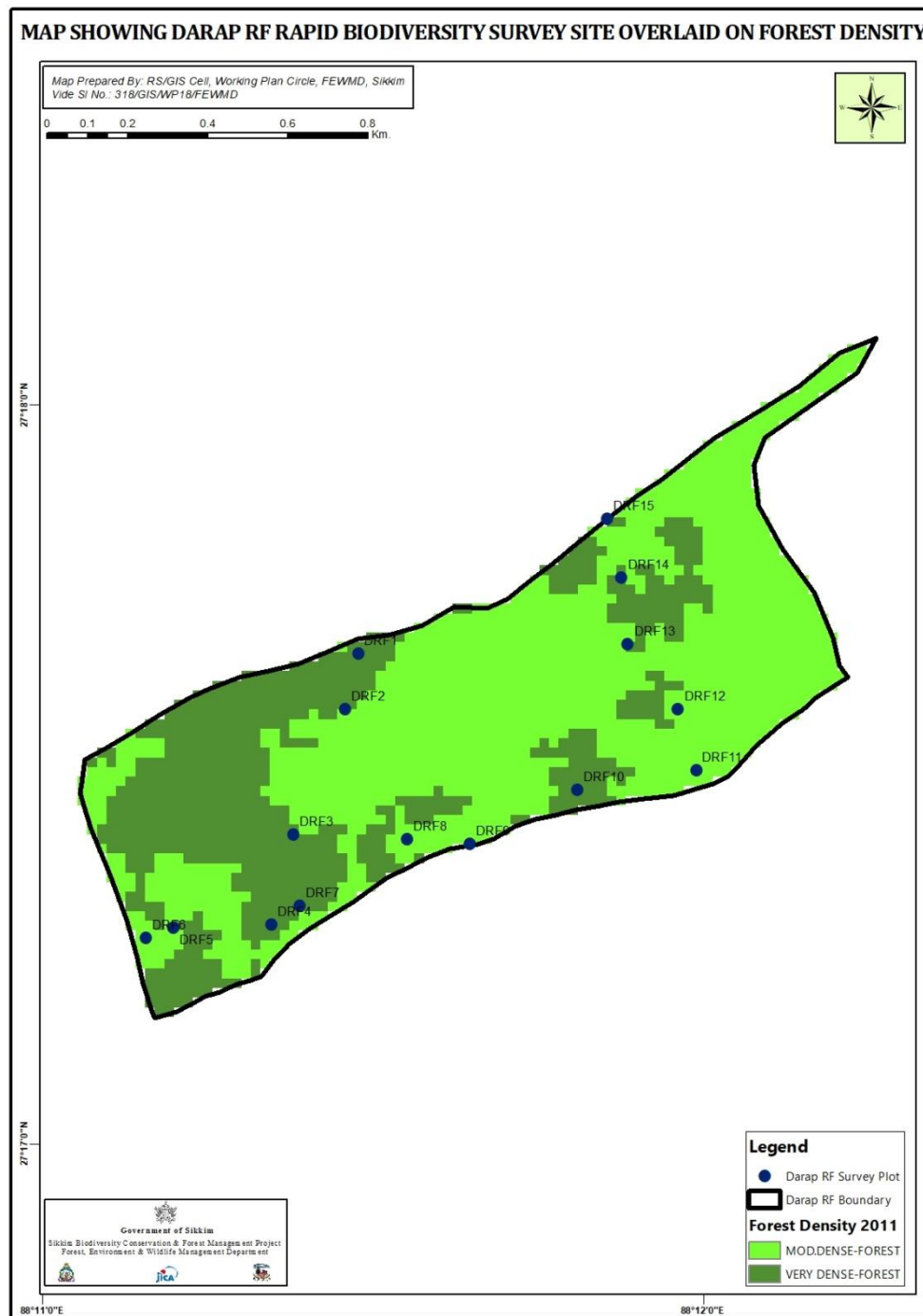


Figure 15a: Rapid biodiversity survey sampling plots showing forest density of Darap Reserve Forest, West Sikkim

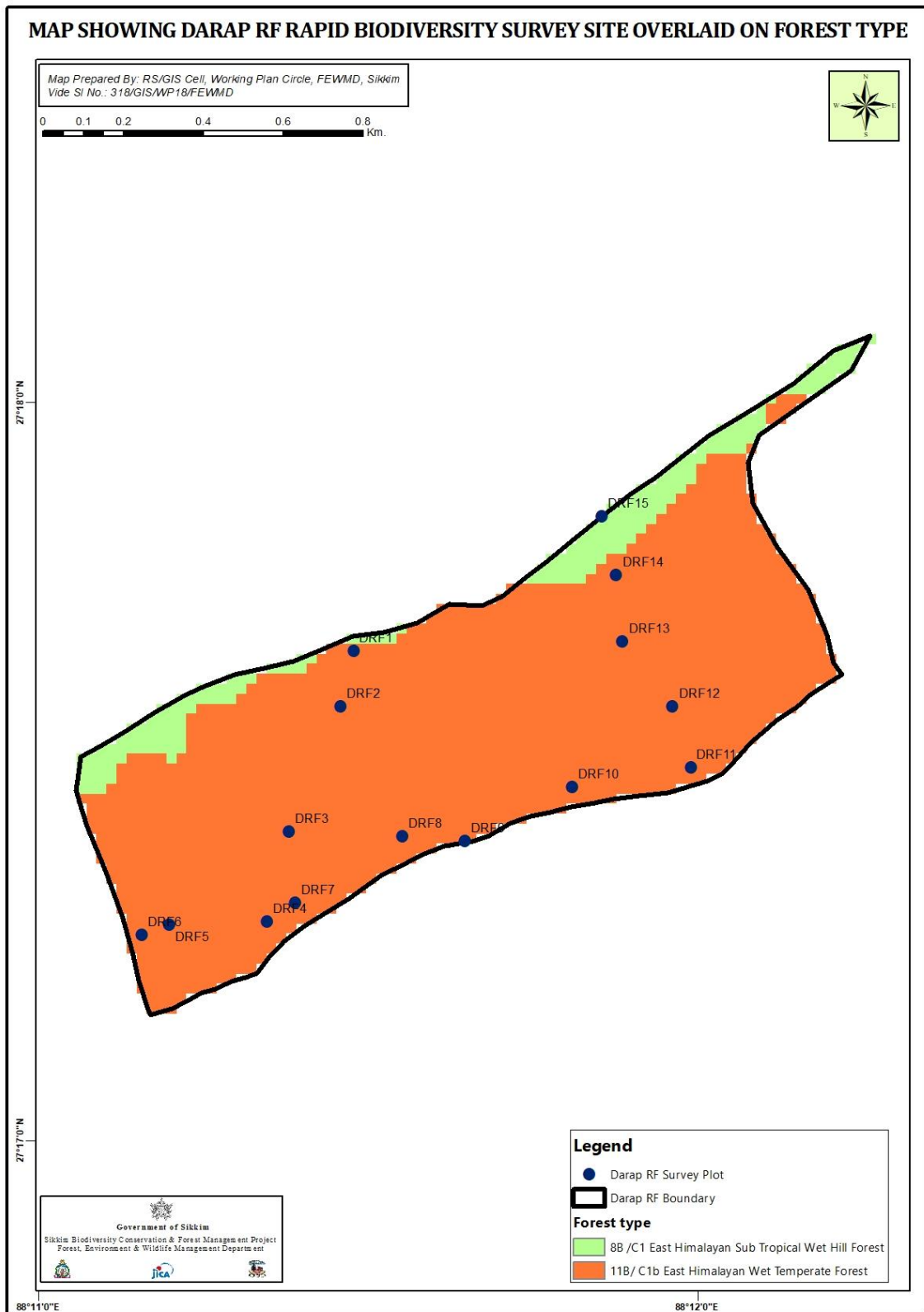


Figure 15b: Rapid biodiversity survey smapling plots showing forest type of Darap Reserve Forest, West Sikkim

Table 17: Site Characteristics of the sampling plots of Darap Reserve Forest, West Sikkim

| Site code | Forest types | Altitude (m) asl | Coordinates | | Slope angle (°) | Slope aspect | Humus depth (cm) | Disturbance | |
|-----------|---------------|------------------|-------------|-------------|-----------------|--------------|------------------|-------------------|---------|
| | | | Latitude | Longitude | | | | Anthropogenic | Natural |
| SRF1 | Wet temperate | 1957 | 27°17'39.6" | 88°11'18.3" | 40 | E | 2 | Fodder collection | |
| SRF2 | Wet temperate | 2021 | 27°17'35.5" | 88°11'17.1" | 60 | NE | 2 | Fodder collection | |
| SRF3 | Wet temperate | 2073 | 27°17'25.0" | 88°11'12.3" | 60 | NE | 2 | | Natural |
| SRF4 | Wet temperate | 2131 | 27°17'17.7" | 88°11'10.2" | 40 | E | 2 | | Natural |
| SRF5 | Wet temperate | 2115 | 27°17'17.5" | 88°11'01.3" | 60 | N | 1.5 | | Natural |
| SRF6 | Wet temperate | 2130 | 27°17'16.7" | 88°10'58.8" | 60 | E | 0.5 | | Natural |
| SRF7 | Wet temperate | 2119 | 27°17'19.2" | 88°11'12.8" | 60 | SW | 2 | | Natural |
| SRF8 | Wet temperate | 2173 | 27°17'23.7" | 88°11'26.7" | 40 | SW | 1 | | Natural |
| SRF9 | Wet temperate | 2202 | 27°17'24.0" | 88°11'39.1" | 60 | N | 1 | | Natural |
| SRF10 | Wet temperate | 2179 | 27°17'28.3" | 88°11'48.9" | 60 | SW | 1 | | Natural |
| SRF11 | Wet temperate | 2141 | 27°17'35.4" | 88°11'55.4" | 50 | SW | 1 | | Natural |
| SRF12 | Wet temperate | 2101 | 27°17'40.4" | 88°11'53.8" | 50 | SE | 2 | | Natural |
| SRF13 | Wet temperate | 2040 | 27°17'45.7" | 88°11'49.3" | 60 | SE | 2 | | Natural |
| SRF14 | Wet temperate | 1969 | 27°17'51.1" | 88°11'48.8" | 50 | S | 2 | Fodder collection | |
| SRF15 | Sub-tropical | 1891 | 7°17'59.0" | 88°11'45.3" | 40 | NW | 2 | | Natural |

plant taxonomist at G.B. Pant Institute (Sikkim Unit) and Botanical Survey of India (BSI), web references (www.efloras.org; www.flowersofindia.net; www.floraofchina) were made and by referring the local people from the nearby villages. All the sampling plots were geotagged for reference under long-term monitoring and altitude was recorded in GPS.

DATA ANALYSIS

Data were analysed for density, frequency, abundance, relative density, relative frequency, relative dominance, Importance Value Index, Species diversity (H), Species richness (I) and Species evenness (E) were calculated using standard formulae. On the basis of girth class, the intervals started from 30cm – 40cm and ended at 691cm – 700 cm at girth at breast height.

RESULTS

A total of 114 plant species belonging to 96 genera and 60 families were recorded from the 15 sampling plots, covering an area of 0.15 ha. Out of which 37 trees, 15 shrubs, 42 herbs, 11 climbers and epiphytes and 9 ferns and fern-allies. Additionally, 12 orchid species

were also recorded. Diversity of vegetation was found most in case of the ground flora in comparison to trees and shrubs (Table 18).

PLANT DENSITY, FREQUENCY AND IMPORTANCE VALUE INDEX

The tree species were recorded cumulatively, viz., adult, sapling and seedling in all the sampling plot. The highest adult individuals were recorded for *Cryptomeria japonica* (180.00Ind/ha) followed by *Symplocos lucida* (186.67Ind/ha), *Symplocos glomerata* (173.33Ind/ha), *Castanopsis indica* (60.00Ind/ha) and *Castanopsis tribuloides* (60.00Ind/ha). Adult individual of *Cryptomeria japonica* was recorded higher density as compared to other species. However, at certain patches the forest department has made plantation of fast growing *Cryptomeria japonica* for the timber purposes. As per the observation, this species is only for timber purposes, the plantation area has 80% dry under the canopy in the forest floor. Other major plant species such as *Castanopsis indica*, *Castanopsis tribuloides*, *Symplocos lucida* and *Symplocos glomerata* in the form of large tree throughout the sampling plot were recorded in mixed temperate forest. The minimum adult density (13.33 Ind/ha) was recorded for *Beilschmiedia sikkimensis*, *Erythrina arborescens*, *Lithocarpus fenestrata* and *Persea odoratissima*. *Symplocos lucida* (933.33 Ind/ha) followed by *Symplocos glomerata* (853.33 Ind/ha) and *Eurya acuminata* (506.67 Ind/ha) were recorded. The minimum sapling density was recorded for *Jambosa formosa* (80.00 Ind/ha).

Table 18: List of plant taxa recorded in Darap Reserve Forest, West Sikkim

| Habit | Species |
|----------------------|------------|
| Tree | 37 |
| Shrub | 15 |
| Herb | 42 |
| Climber and epiphyte | 11 |
| Fern and fern-allies | 9 |
| Total | 114 |

A general structural data regarding density, species diversity, evenness, richness, of the canopy forming species in the study area of the major species is depicted in Table 19. The high relative frequency was occurrence for *Symplocos lucida* (Rel. freq. 9.905) followed by *Symplocos glomerata* (Re. freq. 9.905) and *Castanopsis indica* (Rel. freq. 4.952), respectively. Similarly, high relative frequency occurrence of sapling and seedling for *Symplocos lucida* (Rel. freq. 13.87; 24.55) followed by *Symplocos glomerata* (Re. freq. 11.89; 22.66) and *Eurya acuminata* (Rel. freq. 3.96; 7.55) were recorded. Although some of the matured trees of sapling and seedling were absence due to many factors such as local disturbances by collecting fodder, fuelwood and interference in the forest. The matured tree species such as *Acer campbellii*, *Albizia procera*, *Choerospondias axillaris*, *Cordia myxa*,

Table 19: Availability and distribution of tree species in Darap Reserve Forest, West Sikkim

| Species | Adult | | | Sapling | Seedling |
|---|----------------|-----------|--------|----------------|----------------|
| | Density Ind/ha | A/F Ratio | IVI | Density Ind/ha | Density Ind/ha |
| <i>Acer campbellii</i> Hook. & Thom. Ex Hiern. | 20.000 | 0.11250 | 3.492 | | |
| <i>Albizzia procera</i> Benth. | 20.000 | 0.11250 | 3.428 | | |
| <i>Alnus nepalensis</i> Don. | 53.333 | 0.13333 | 7.138 | 186.67 | 2666.67 |
| <i>Beilschmiedia sikkimensis</i> King ex Hook. f. | 13.333 | 0.07500 | 3.369 | | |
| <i>Betula cylindrostachya</i> Lindl. ex Wall. | 20.000 | 0.11250 | 3.426 | | |
| <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. | 53.333 | 0.13333 | 6.856 | 133.33 | 6666.67 |
| <i>Castanopsis tribuloides</i> (Smith) A. DC. | 60.000 | 0.15000 | 8.125 | 106.67 | 7333.33 |
| <i>Castanopsis indica</i> (Roxb. ex Lindl.) A.DC. | 60.000 | 0.05400 | 11.545 | 133.33 | 5333.33 |
| <i>Choerospondias axillaris</i> (Roxb.) B.L.Burt & A.W.Hill | 20.000 | 0.11250 | 3.664 | | |
| <i>Cordia myxa</i> L. | 20.000 | 0.11250 | 3.436 | | |
| <i>Cryptomeria japonica</i> (Thunberg ex. Linn. F.) D. Don | 180.000 | 1.01250 | 19.908 | 80.00 | 35333.33 |
| <i>Duabanga sonneratioides</i> Ham. | 20.000 | 0.11250 | 3.439 | | |
| <i>Erythrina arborescens</i> Roxb. | 13.333 | 0.07500 | 2.957 | | |
| <i>Eurya acuminata</i> | 20.000 | 0.11250 | 3.373 | 506.67 | 10666.67 |
| <i>Exbucklandia populnea</i> (R. Br. Ex Griff) R. W. Br | 20.000 | 0.11250 | 3.480 | | |
| <i>Ficus nemoralis</i> | 53.333 | 0.07500 | 7.709 | 133.33 | |
| <i>Jambosa formosa</i> (Wall.) G. Don. | 20.000 | 0.11250 | 3.499 | 80.00 | 2000.00 |
| <i>Juglans regia</i> L. | 33.333 | 0.18750 | 4.525 | 186.67 | 3333.33 |
| <i>Lithocarpus fenestrata</i> Roxb. | 13.333 | 0.07500 | 3.128 | | |
| <i>Lithocarpus pachyphyllus</i> (Kurz) Rehder | 33.333 | 0.18750 | 5.596 | | 2666.67 |
| <i>Lyonia ovalifolia</i> var. <i>ovalifolia</i> | 26.667 | 0.06667 | 4.884 | 106.67 | 2666.67 |
| <i>Macaranga denticulata</i> (Blume) Müll.Arg. | 20.000 | 0.11250 | 3.422 | | |
| <i>Maesa</i> sp. | 20.000 | 0.11250 | 3.427 | | |
| <i>Magnolia doltsopa</i> | 26.667 | 0.15000 | 3.843 | | |
| <i>Magnolia velutina</i> DC. | 20.000 | 0.11250 | 86.388 | | |
| <i>Myrsine semiserrata</i> Wall | 20.000 | 0.11250 | 3.457 | | |
| <i>Nyssa javanica</i> (Blume) Wangerin | 20.000 | 0.11250 | 3.454 | | |
| <i>Ostodes paniculata</i> (D. Don) DC | 20.000 | 0.11250 | 3.373 | | |
| <i>Pandanus nepalensis</i> | 20.000 | 0.11250 | 3.373 | | |
| <i>Persea odoratissima</i> (Nees) Kosterm. | 13.333 | 0.07500 | 3.069 | | |
| <i>Quercus lamellosa</i> Sm. | 33.333 | 0.08333 | 6.258 | 213.33 | 5333.33 |
| <i>Rhus chinensis</i> | 20.000 | 0.11250 | 3.373 | | |
| <i>Rhus succedanea</i> Linn. | 20.000 | 0.05000 | 4.719 | | |
| <i>Symplocos glomerata</i> King ex C.B. Clarke | 173.333 | 0.03900 | 22.956 | 853.3 | 45333.3 |
| <i>Symplocos lucida</i> (Thunb.) Siebold & Zucc | 186.667 | 0.04200 | 23.663 | 933.3 | 35333.3 |
| <i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg | 20.000 | 0.11250 | 3.451 | | |
| <i>Tetradium fraxinifolium</i> (Hook. f.) T.G. Hartley | 20.000 | 0.11250 | 3.458 | | 2000 |
| <i>Zanthoxylum acanthopodium</i> DC | 20.000 | 0.11250 | 3.373 | | |

Duabanga sonneratioides, *Erythrina arborescens*, *Exbucklandia populnea*, *Lithocarpus fenestrata*, *Lithocarpus pachyphyllus*, *Macaranga denticulata*, *Maesasp.*, *Magnolia doltsopa*, *Magnolia velutina*, *Myrsine semiserrata*, *Nyssa javanica*, *Ostodes paniculata*, *Pandanus nepalensis*, *Persea odoratissima*, *Rhus chinensis*, *Rhus succedanea*, *Terminalia myriocarpa*, *Tetradium fraxinifolium* and *Zanthoxylum acanthopodium* were recorded (**Figure 16**).

The forest stands characterized by an abundance and frequency of adult canopy and sub canopy species. The sapling and seedling populations were low which are expected to face local extinction of some species. The increasing biotic pressure may cause a drastic reduction in regeneration of several species.

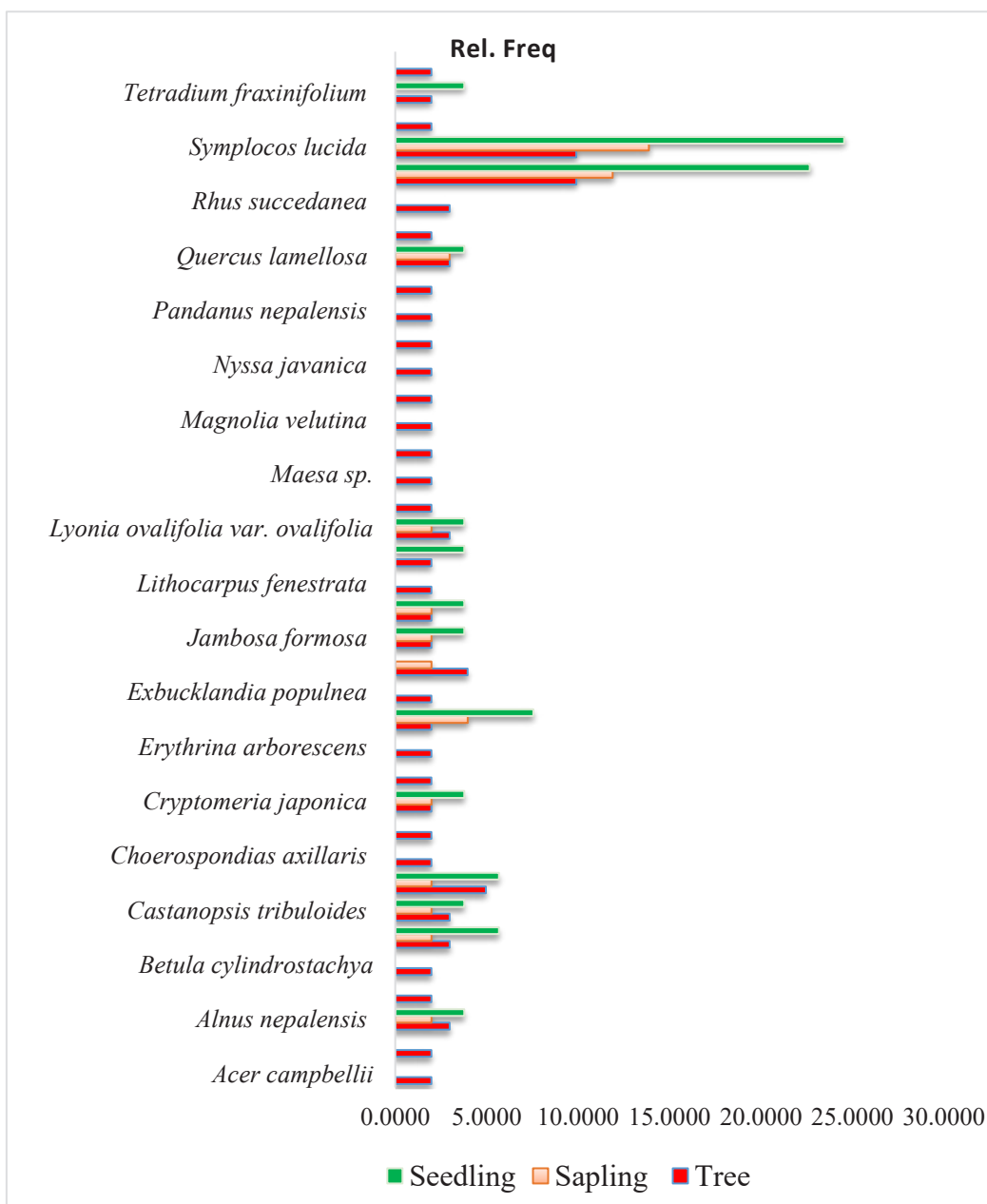


Figure 16: Relative frequency of major species along the sampling plots

DISTRIBUTION PATTERNS (A/F) RATIO

The abundance to frequency ratio revealed all the adult individual of large tree species to be contagiously distribution except for *Rhus succedanea*, *Symplocos glomerata* and *Symplocos lucida* which showed the random distribution but none of the species showed regular distribution.

IMPORTANCE VALUE INDEX (IVI)

The highest Importance Value Index (IVI) was recorded for *Magnolia velutina* (86.38) followed by *Symplocos lucida* (23.66), *S. glomerata* (22.95), *Cryptomeria japonica* (19.90) and *Castanopsis indica* (11.54) (Figure 17).

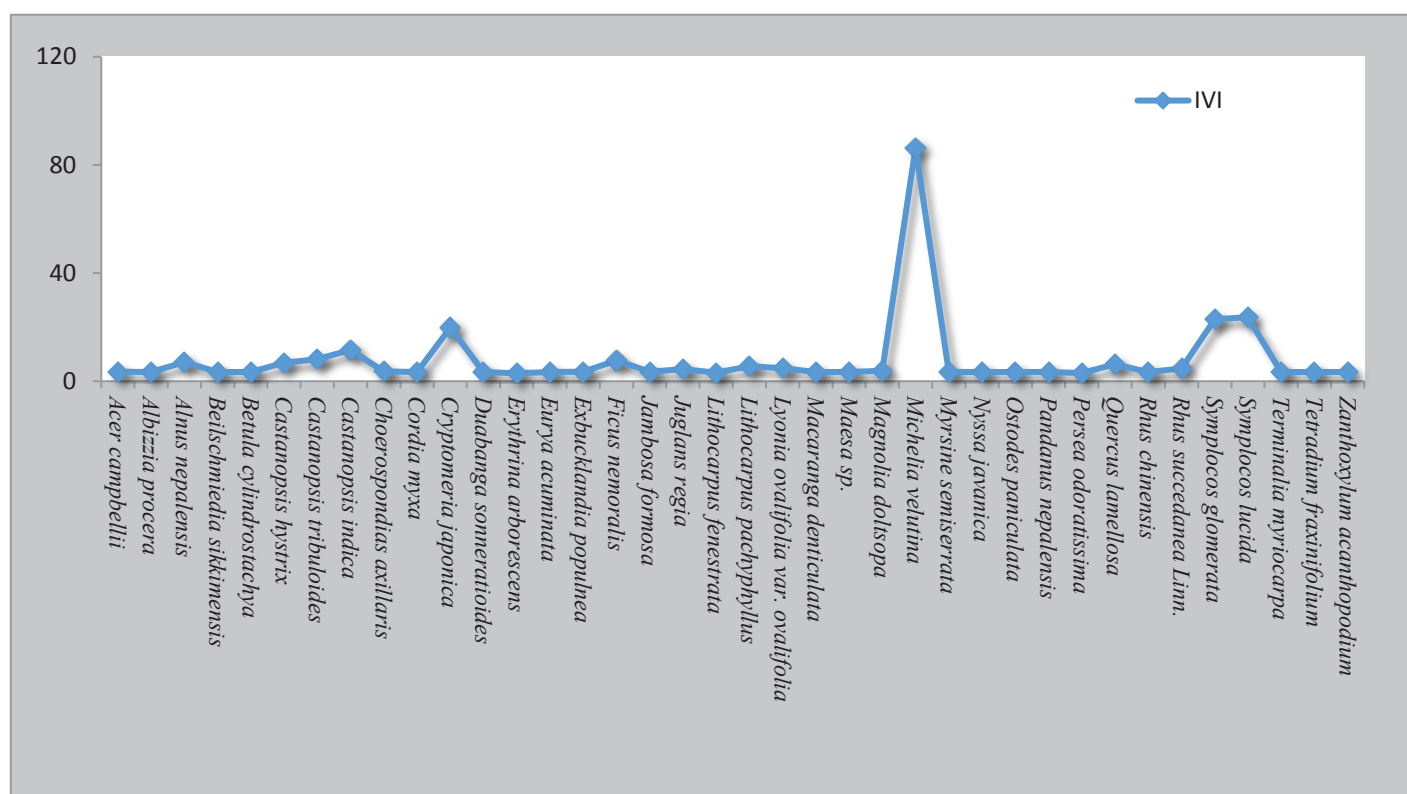


Figure 17: Importance value index of major tree species

SPECIES RICHNESS AND DIVERSITY PARAMETERS

Many different measures of biodiversity have been developed by ecologist. Species richness represents the number of species available in a given area. The highest species richness was recorded for tree (37.813) followed by seedling (13.819) and sapling (12.797) as shown in Table 20. The higher tree species richness showed an increased forest with decreasing disturbance

in the forest especially in the case of tree. That means the regeneration potential is higher in the present study area.

A greater number of species in a community is ecologically important as diversity seems to increase with increasing community stability. Community studies are usually conducted on mature trees along with saplings and seedlings to determine the structure of the forest.

| Table 20: Species diversity of tree, sapling and seedling along the sampling path of Darap Reserve Forest, West Sikkim | | | |
|---|-------------|----------------|-----------------|
| Parameters | Tree | Sapling | Seedling |
| Species Diversity (H) | 3.230 | 2.168 | 2.057 |
| Species Richness (I) | 37.813 | 12.797 | 13.819 |
| Species Evenness (E) | 0.888 | 0.845 | 0.779 |

A comparatively smaller number of species observed in the present study may be limited to species restricted to the sampling area only. The forest types and elevation play a significant role in the forest ecosystem. Species diversity which considers two aspects, species richness and evenness are commonly used as a measure for forest structure. The Shannon – Wiener’s Index increases as both the richness and the evenness of the community increases.

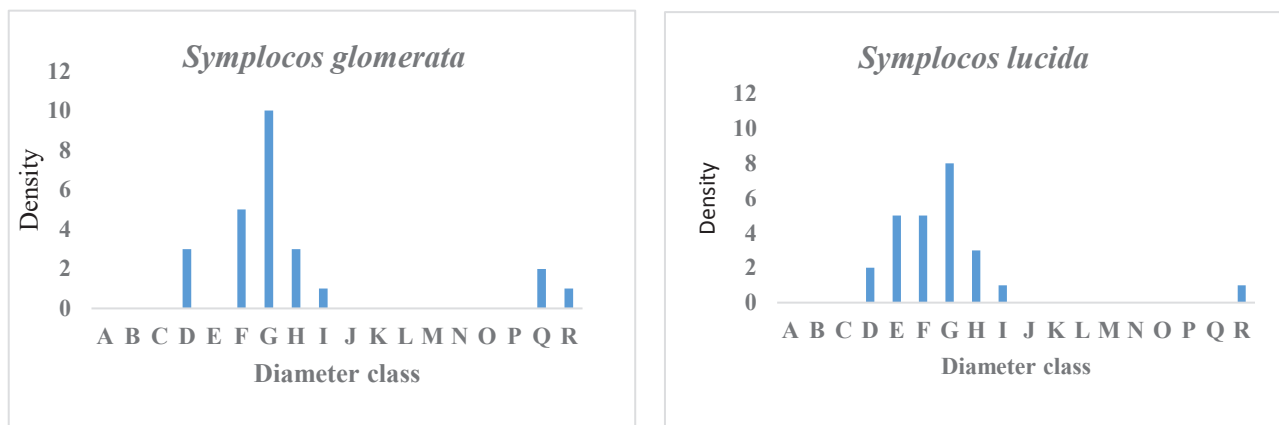
In the present study, the Shannon – Wiener’s Index (H) showed that it was much higher for trees (3.230) followed by sapling (2.168) and seedling (2.057). The value of diversity index was found to be falling between 2.057 to 3.320 which is a good diversity value for temperate forest.

GIRTH CLASS

On the basis of girth class, the intervals started from 30cm – 40cm and ended at 691cm – 700cm at gbh. The girth class of dominant species as well as a few major tree species was calculated to understand the community structure.

In the case of *Cryptomeria japonica*, several classes of girth were found missing and sometimes large gaps appeared between the two classes. In the case of *Symplocos lucida* and *Symplocos glomerata*, the maximum girth classes between D to I classes were recorded and there was no large matured tree recorded (**Figures 18 & 19**). It should be noted that some of the species started with a size class between 30cm and 40cm but were still not the same. It may be suggested that the trees may have a wide distribution range which is generally supported by the site characteristics.

The most dominant taxa in the study area are *Symplocos glomerata* and *Symplocos lucida*. For *Symplocos glomerata*, girth classes of 61 – 70 were recorded and that there was a gap between 71cm – 80cm gbh. The girth classes was gently showing natural continuum of girth classes as normal after 80cm gbh. After that gap between J – P diameter classes. Similarly, for *Symplocos lucida*, the diameter classes were in between 61cm – 70cm and 111cm – 120cm and there are several gaps between them suggesting that it is not normal or natural due to anthropogenic pressure in the area.



Figures 18 & 19: Diameter classes of *Symplocos glomerata* and *Symplocos lucida*

As per the family-wise species composition of shrub species, the greater family was recorded for Thymeleaceae followed by Hydrangaceae (Figure 20). In respect to percent cover of shrub species, the highest percent cover was recorded at 32% for *Osbeckia stellata* followed by *Rubus ellipticus* at 16% and *Polygonum molle* at 10%. The lowest cover presence of 0.968 was found in *Leucosceptrum cannum* and *Daphne cannabina* (Figure 21).

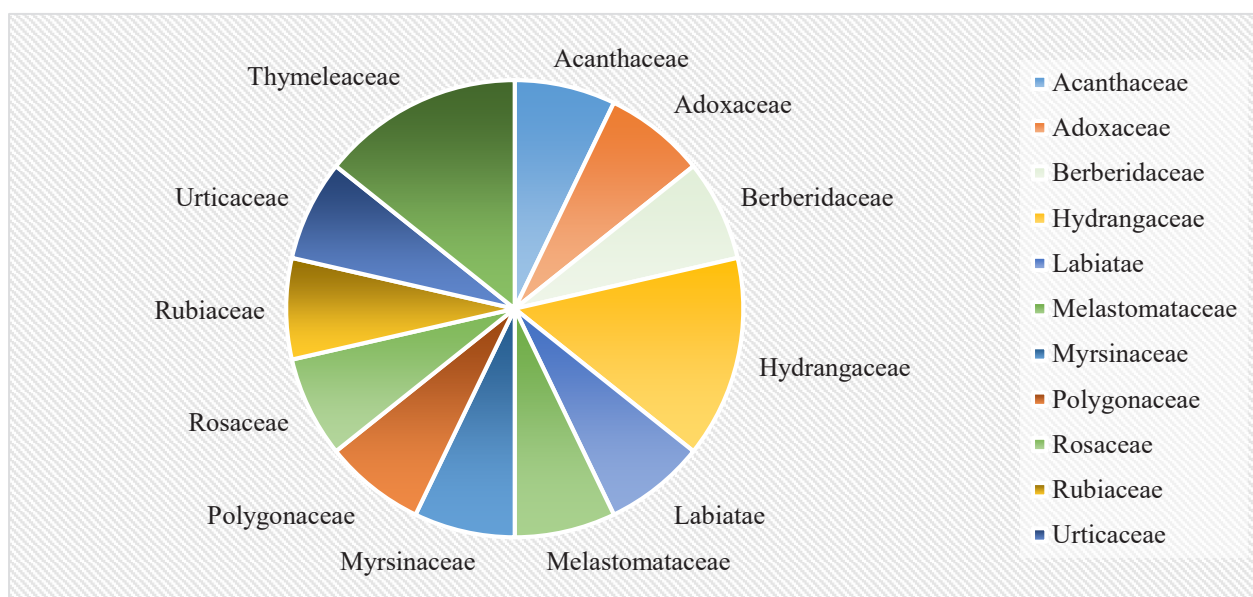


Figure 20: Family-wise species composition of shrub species

The most dominant and wide distribution taxa is *Osbeckia stellata* found growing from subtropical to temperate forest. *Polygonum molle* and *Leucosceptrum cannum* are those plants which have only known colored nectar plants and have essential ecosystem services in the forest.

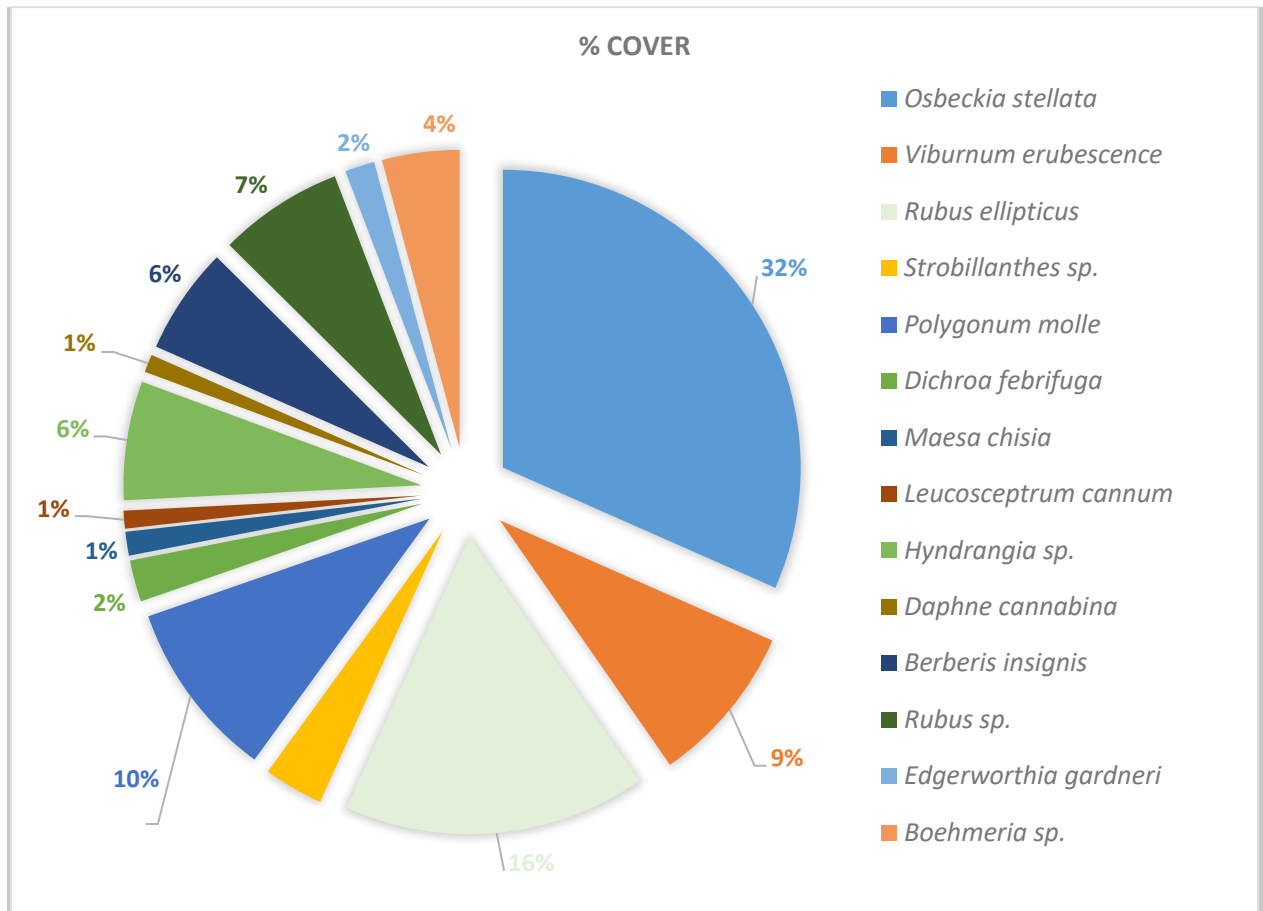


Figure 21: Percent cover of shrub and scrub species

HERB

For herb category, the highest percent was recorded for *Eragrostis sp.* and *Fragaria nubicola* (18.9% each) followed by *Diplazium stoliczkae* (16.7%), *Lycopodium japonicum* (13.8%). The lowest herb species was recorded for *Swertia bimaculata* (0.4%) followed by *Laportea terminalis* (0.7%) as shown in **Figure 22**.

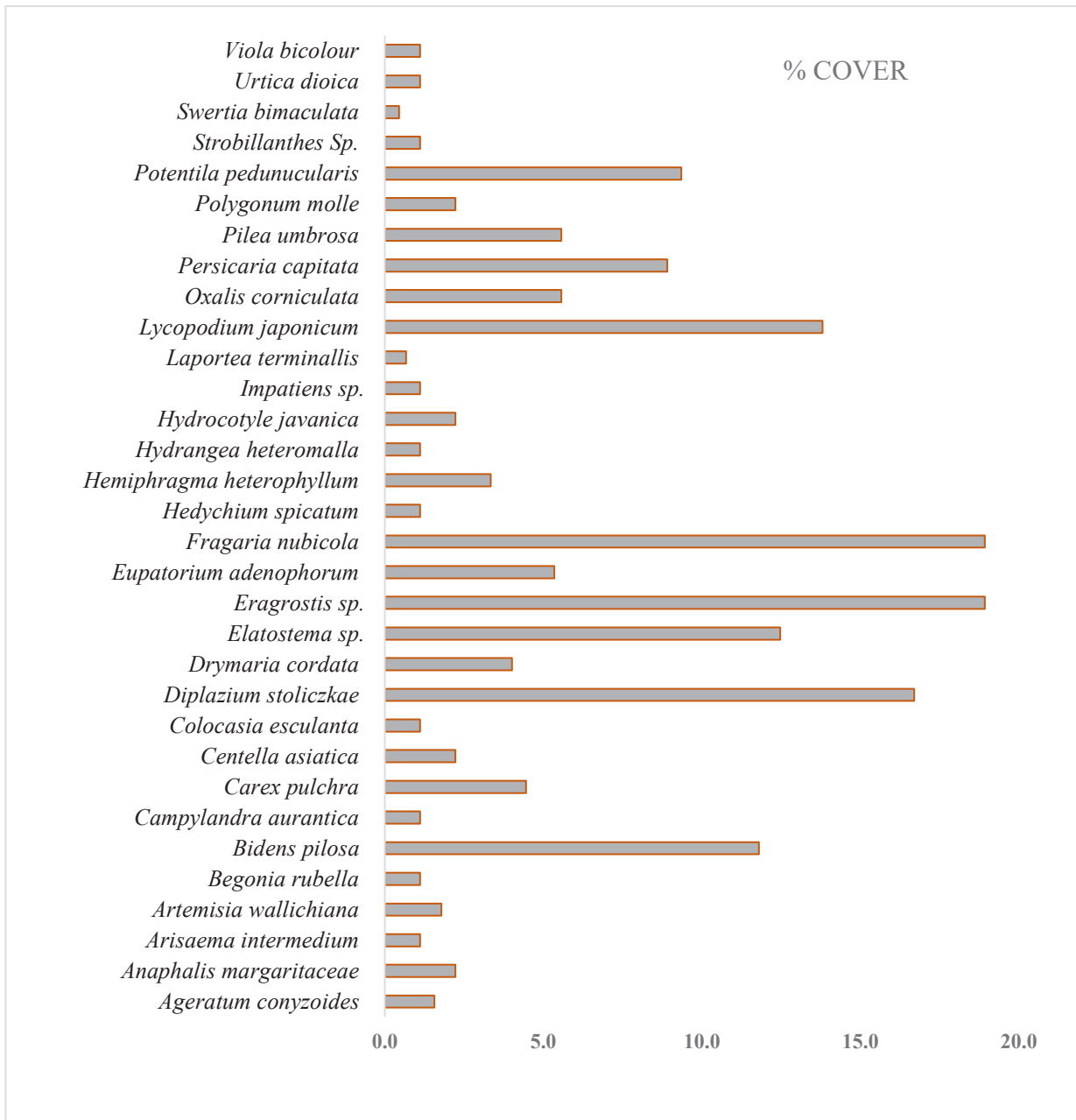


Figure 22: Percent cover of herb species recorded along the sampling plots

FAUNAL DIVERSITY

During the survey, 4 species of animals were recorded from Darap Reserve Forest. Further, a total of 21 bird species belonging to 14 families were recorded. The family-wise bird species composition were recorded for Turdidae and Corvidae (3 species each) followed by Dicaeidae, Paridae, Phasinidae (2 species each) from the transect. The other remaining family was represented by single species (**Figure 23; Table 21**).

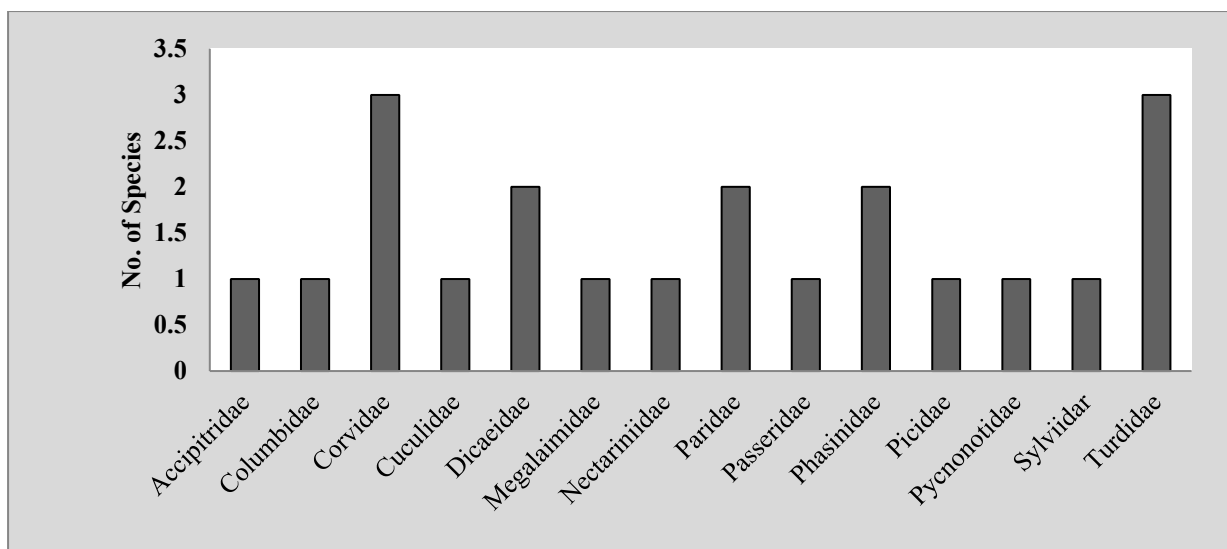


Figure 23: Family-wise bird species composition of Darap Reserve Forest

Table 21: Checklist of fauna and avi-fauna species encountered at Darap Reserve Forest, West Sikkim

| Sl. No | Scientific Name | Family | Common Name | Local Name |
|------------------|---------------------------------|---------------|------------------------------|-------------|
| FAUNA | | | | |
| 1. | <i>Muntiacus muntjak</i> | Cervidae | Barking deer | Mirga |
| 2. | <i>Ursus thibetanus</i> | Carnivora | Himalayan black bear | Ban kukur |
| 3. | <i>Cuon alpinus</i> | Carnivora | Wild dog | Bhalu |
| 4. | <i>Sus scrofa</i> | Suidae | Wild pig | Bodyal |
| 5. | <i>Canis sp.</i> | Carnivora | Common jackal | Syall |
| AVI-FAUNA | | | | |
| 1. | <i>Aegoithalos louschistos</i> | Paridae | Rufous-fronted tit | Fista |
| 2. | <i>Cettia major</i> | Sylviidae | Chestnut-crowned warbler | Fista |
| 3. | <i>Fulvetta vinipectus</i> | Paridae | Coal tit | Fista |
| 4. | <i>Corvus macrorhyncus</i> | Corvidae | Jungle crow | Khag |
| 5. | <i>Cuculus canorus</i> | Cuculidae | Eurassian | Cuckoo |
| 6. | <i>Dendrocopos darjellensis</i> | Picidae | Darjeeling woodpecker | Laachey |
| 7. | <i>Dicrurus leucophaeus</i> | Dicaeidae | Ashy drongo | Chibey |
| 8. | <i>Dicrurus macrocercus</i> | Dicaeidae | Black drongo | Chibey |
| 9. | <i>Garrulax leucolophus</i> | Turdidae | White-crested laughingthrush | Kolkoley |
| 10. | <i>Garrulax ocellatus</i> | Turdidae | Spotted laughingthrush | Kolkoley |
| 11. | <i>Gypaetus barbatus</i> | Accipitridae | Lammergeier | Chill |
| 12. | <i>Lophura leucomelana</i> | Phasinidae | Kalij pheasant | Kalij |
| 13. | <i>Megalaima virens</i> | Megalaimidae | Great barbet | Neual |
| 14. | <i>Myophonus caeruleus</i> | Turdidae | Blue whistling thrush | Kalchura |
| 15. | <i>Passer rutilans</i> | Passeridae | Russet sparrow | Bhangera |
| 16. | <i>Pycnonotus cafer</i> | Pycnonotidae | Red-vented bulbul | Jureli |
| 17. | <i>Streptopelia orientalis</i> | Columbidae | Oriental turtle dove | Dhukur |
| 18. | <i>Urocissa ornata</i> | Corvidae | Yellow-billed blue magpie | Lampucharey |
| 19. | <i>Corvus macrorhyncus</i> | Corvidae | Large-billed crow | Kag |
| 20. | <i>Arborophila torqueola</i> | Phasinidae | Hill partridge | Peura |
| 21. | <i>Aethopygia nicauda</i> | Nectariniidae | Fire-tailed sunbird | Balchi |

DISCUSSIONS

The present study reveals a floral assemblage of 114 number of plant species in an estimated 0.15 ha of study area, which is slightly more as compared to 88 species in 0.064 ha by Subba *et al.* 2017 (**Annexure 3**). This figure is more as compared with the recent figure of Sikkim (5500 species in 7096 sq.km) as considered as rich biodiversity. Higher density was recorded for *Cryptomeria japonica* followed by *Symplocos lucida* and *Symplocos glomerata*. Some of the mature trees of sapling and seedling was absence due to local interferences. There might also be the reasons which may be connected to human infringement during the process of plant community development. The trees have a broad distributional range.

The findings of the present study revealed that the herb represents the highest number of species as followed by tree species. The herbs play a significant role in the forest floor of mixed temperate forest, as the sunlight easily penetrate into the ground and the rich diversity of herb species was recorded. Similarly, the low density of seedlings and young trees was recorded due to large fragments caused by low light intensity on the forest floor in wet temperate forest. In the *Oak* temperate forest, the light intensity was low cause of closed canopy cover but the soil moisture level was high and intensity of disturbances was low revealed the good regeneration potential in the forest. Some of the taxa show enhanced reproduction and growth in the forest floor. The shrubs and climber have symbiotic relationship between them. The maximum number of climber species was recorded.

The highest IVI value recorded for *Magnolia velutina* which makes it the dominant species in the site with the figure (86.38) far above the other contender viz., *Symplocos lucida* (23.66), *Symplocos glomerata* (22.95), and *Cryptomeria japonica* (19.90) and *Castanopsis indica* (11.54). Similarly, the middle canopy cover in most of the temperate forest is dominated by *Symplocos lucida* and *Symplocos glomerata*. This fact is additionally strengthened from the A/F ratio taken to analyse species distribution. The abundance to frequency ration revealed all the adult individual of large tree species to be contagiously distribution except for *Rhus succedanea*, *Symplocos glomerata* and *Symplocos lucida* which showed the random distribution but none of the species showed regular distribution. A number of tree species found in the Himalaya showed varying patterns of distribution (Sharma *et al.* 2009).

The value of species richness in the present study was found to be falling between 37.81 – 12.79. The species richness was higher recorded for tree (37.81) followed by seedling (13.81) and sapling (12.79). Generally, species richness declines with increasing elevation (Stevens 1992). At higher elevation, the rate of N mineralization and nitrification decreases resulting in slow rate of plant growth, competitive exclusion and normality as a consequence of cooler temperature (Heaney and Proctor 1989).

The Shannon-Wieners's Index (H) showed that it was much higher for trees (3.230) followed by sapling (2.168) and seedling (2.057). The value of diversity index in the present study was found to be falling between 2.057 and 3.320. This figure, in the mixed temperate forest is higher value of species diversity. The diversity index is a highly fluctuating figure and is variously assigned to 2-3 for temperate forest (Risser & Rice 1971) or index is generally higher in temperate forest between 1.16 to 3.40 (Braun 1950), whereas for Indian forests it ranged between 0.83 to 4.1 (Singh *et al.* 1984; Parthasarthy *et al.* 1992; Visalakshi 1995). However, this figure stands out, undisturbed natural forest which are usually found to be largest number plants species in the forest. The numbers of individual always progressively increase from the adult mature tree towards seedlings. That means the area has much dense forest by many other keystone species. Keystone species play significant role, both in maintaining species diversity and the health of an ecosystem.

Regarding girth classes, the *Symplocos glomerata* girth classes of 61-70 were recorded and that there is a gap between them 71-80cm gbh after that the girth classes was gently showing natural continuum of girth classes as normal. After that gap between J-P diameter classes. Similarly, for *Symplocos lucida*, the diameter classes were in between 61-70 and 111-120 and there are several gaps between them which suggest that it is not normal or natural due to anthropogenic pressure in the area.

For shrub, the most dominant taxa are *Osbeckia stellata* in the present study site which is found growing in subtropical to temperate forest. *Polygonum molle* and *Leucosceptum cannum* are those plants which have only known colored nectar plants. Many species of birds were attracted in its floral nectar plants which play significant role as food resources thus, contributing to rich diversity of avian species. Conservation of biological diversity must be devised for long term adequate protection of some of the important species.

The herbs are an important component of deciduous forest. However, since many herbaceous species do not persist in the forest seed bank, populations may not return with the

cessation of disturbance (Pickett and McDonnell 1989) because they disperse over only limited distances, up to a few meters (Willson 1993; Cain *et al.* 1998). In the present study, the edible plants such as *Laportea terminalis* and *Diplazium stoliczkae* were recorded.

It is concluded that the present rapid biodiversity assessment found that the temperate forest has high diversity of floral species. So, it is suggested that rapid survey needs to be conducted on a seasonal basis to get the overall picture of alpha diversity of the species.



Green-tailed sunbird (Female)

Quantitative Analysis of Vegetation of Maniping Reserve Forest Sampling Path in West Sikkim, India

Nimesh Chamling, Anjana Pradhan & Dorjee Chewang Bhutia



Photo 9: View of Khangchendzonga Range from Maniping Reserve Forest

INTRODUCTION

According to Medeiros & Torezan (2012), the need for quick identification of priority areas for biodiversity protection makes rapid assessment methods important tools used by conservationists and managers for defining conservation strategies. The main objective of rapid assessment methods is to assess the ecological status of ecosystems quickly and inexpensively using a finite set of observable indicators in the field (Abate 1992; Sayre *et al.* 2000; Sutula *et al.* 2006; Allen 2009; Stein *et al.* 2009). REA was originally developed by The Nature Conservancy, a nongovernmental organization, and was first used in the subtropical rainforest of Mbaracayú in Paraguay to identify priority habitats for conservation (Abate 1992). Since then, it has been applied in several habitat types, from coral reefs (e.g., Maragos and Cook 1995), to wetlands (Fennessy *et al.* 2007), to tropical forests (Jones and Eggleton 2000).

India is recognized as one of the 12 mega diversity centers of the world. With only 2.4% of the earth's land area, India accounts for 7-8% of the recorded species in the world. Out of the 34 biodiversity hot-spots in the world recognized by UNESCO, India owns 2, namely the Western Ghats and the Eastern Himalaya. Sikkim covering just 0.2 % of the

geographical area of the country has 26% of the country's total biodiversity and has been identified as one of the HOT-SPOT in the Eastern Himalayas. Sikkim falls under Himalayan (2) Bio-geographic zone & Central Himalaya (2c) biotic province having about 9 types of forests types (Champion & Seth).

The State is endowed with rich floral and faunal diversity. Species wise, the State harbors over 5500 flowering plants, 557 Orchids, 38 Rhododendrons, 16 Conifers, 28 Bamboos, 362 Ferns and its allies, 9 Tree Ferns, 30 Primulas, 11 Oaks, 1681 Medicinal plants, 144+ mammals, 568 Birds, 48 Fishes, and over 689 Butterflies and 7000 species of Moths. While these figures are still not absolute, it may be kept in mind that this is only the mega-fauna and flora. The tremendous diversity of insects like beetles and moths as well as a host of other life forms is yet to be enumerated. Most of the high altitude medicinal plants are rare and endangered species. Sikkim also has 28 Mountains/Peaks, more than 80 Glaciers, 534 high altitude lakes/wetlands and over 104 rivers and streams (http://sikenvis.nic.in/Database/Biodiversity_776.aspx).

This paper is basically an attempt to highlight the present phytosociological status of Maniping Reserve Forest in West Sikkim. The objective of this paper is to describe the vegetation structure, plant species composition and diversity of the RF. Maniping Reserve Forest with an area of 12.51 sq.km and 1250.70 in Ha comes under the purview of West Sikkim Territorial Division and falls under the Dentam Range. The Reserve Forest is located between latitude 27°16'53.3"N-27°16'24.5"N and longitude 88°03'15.7"E-88°02'49.0"E. The variation in altitude ranges from 2423-3150m above sea level (asl). The RF is approximately 10.1 km from Uttarey.



Photo 10: Alpine meadow at Maniping Reserve Forest

SURVEY AREA

The current survey was carried out along the trekking route of Maniping Reserve Forest (**Figure 24a, b & c**). The altitude of the surveyed path ranged from 2423m to 3150m asl lying between 27°16'53.3"N-27°16'24.5"N latitude and 88°03'15.7"E-88°02'49.0"E longitude. The slope angle of the surveyed area ranged from 15° to 55° and aspect facing towards N, E, NE and S (**Table 22**). The Reserve Forest lies in West Sikkim under West Territorial Division, Headquarter at Geyzing. The field visit was done in October 2017. Survey design that includes a hierarchy of progressively finer scale gradients can significantly improve the chances of locating biota and increases the probability of locating rarities (Gillison and Brewer 1985; Wessels *et al.* 1998).

Random sampling was done using a standard quadrat method by laying 10 plots of 10m x 10m at every 70 – 100m distance depending upon the site feasibility. General listing of floral species outside the plots were also done to have fair idea on the species availability in the area. Species were identified in the field using previous field experiences as well as the published floral references (<http://www.flowersofindia.net/>; <http://www.efloras.org/>; <http://www.theplantlist.r/>) including standard floras (Hooker 1849; Polunin & Stainton 1987; Pradhan & Lachungpa 1990) and global/regional threat status of each species was identified using web resources (www.iucnredlist.org). The unidentified specimens were photographed and/or collected and identified later by consulting plant taxonomists, herbaria and literature.

Data were quantitatively analyzed for density, frequency and abundance, relative density, relative frequency, relative dominance, Importance Value Index (IVI), species diversity (H) and species richness (I) using standard formulae. On the basis of girth class, the intervals started from 30cm – 40cm and ended at 691cm – 700 cm at gbh.

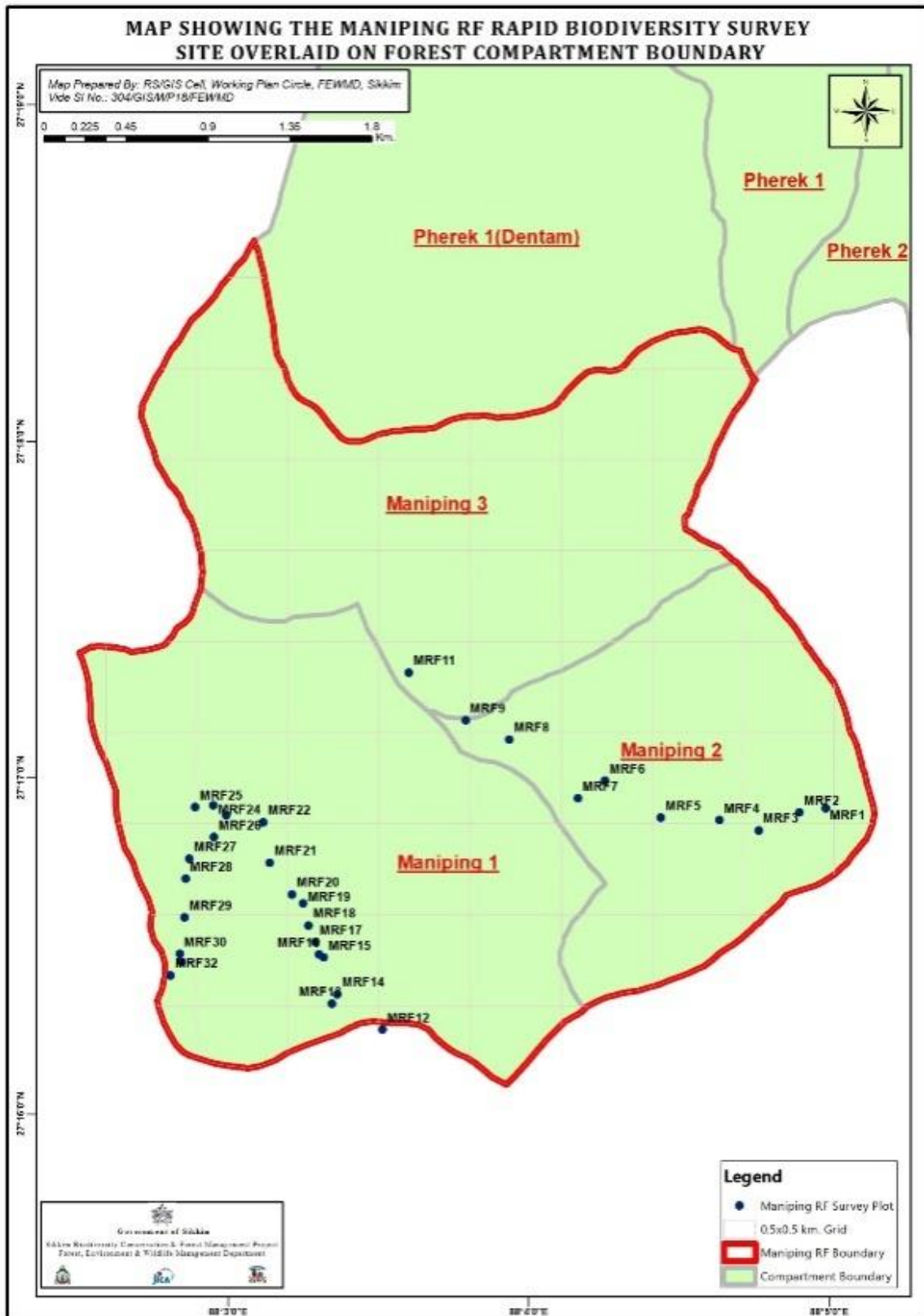


Figure 24a: Rapid biodiversity survey plots along Maniping RF covering forest compartment

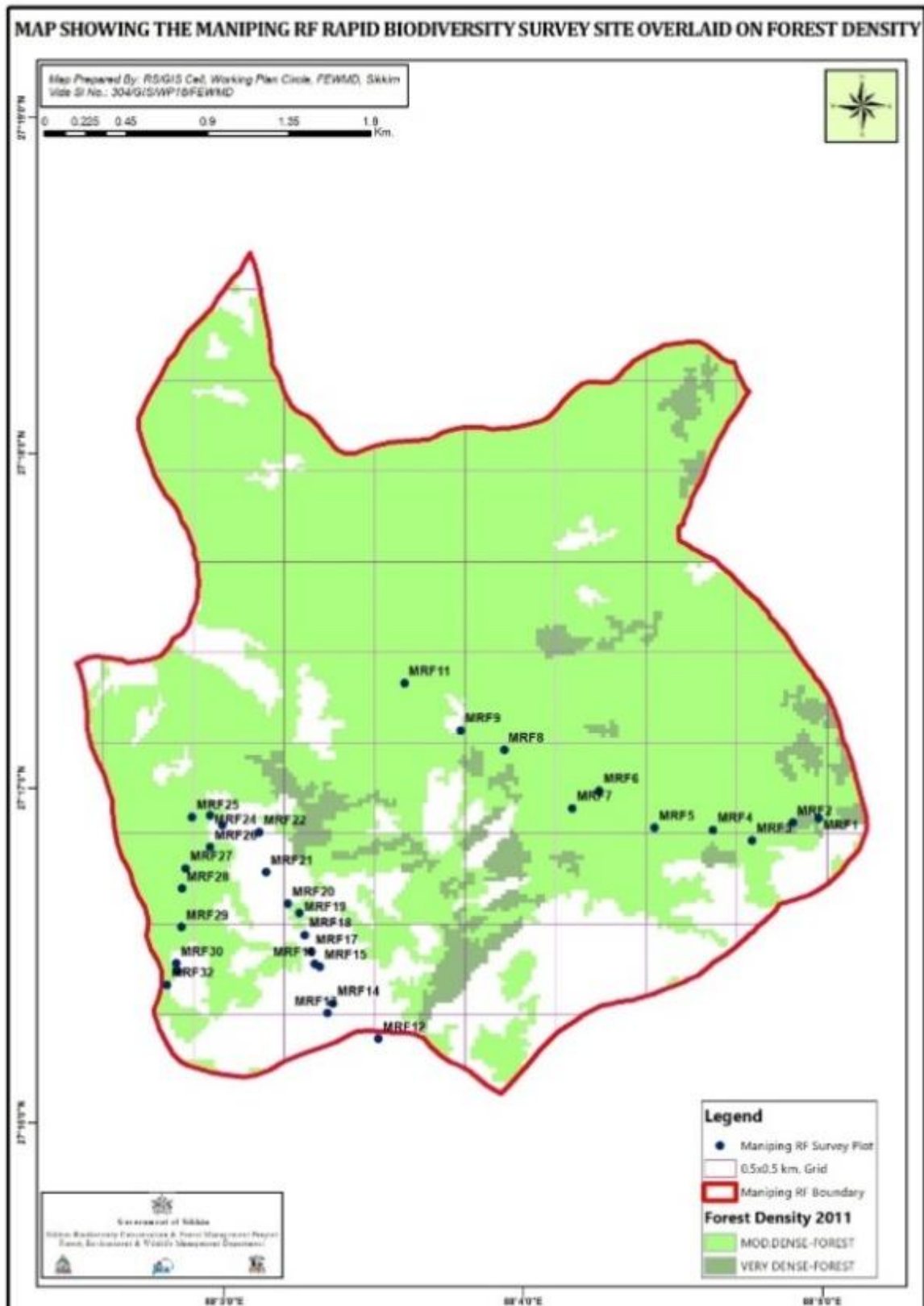


Figure 24b: Rapid biodiversity survey plots along Maniping RF covering forest density

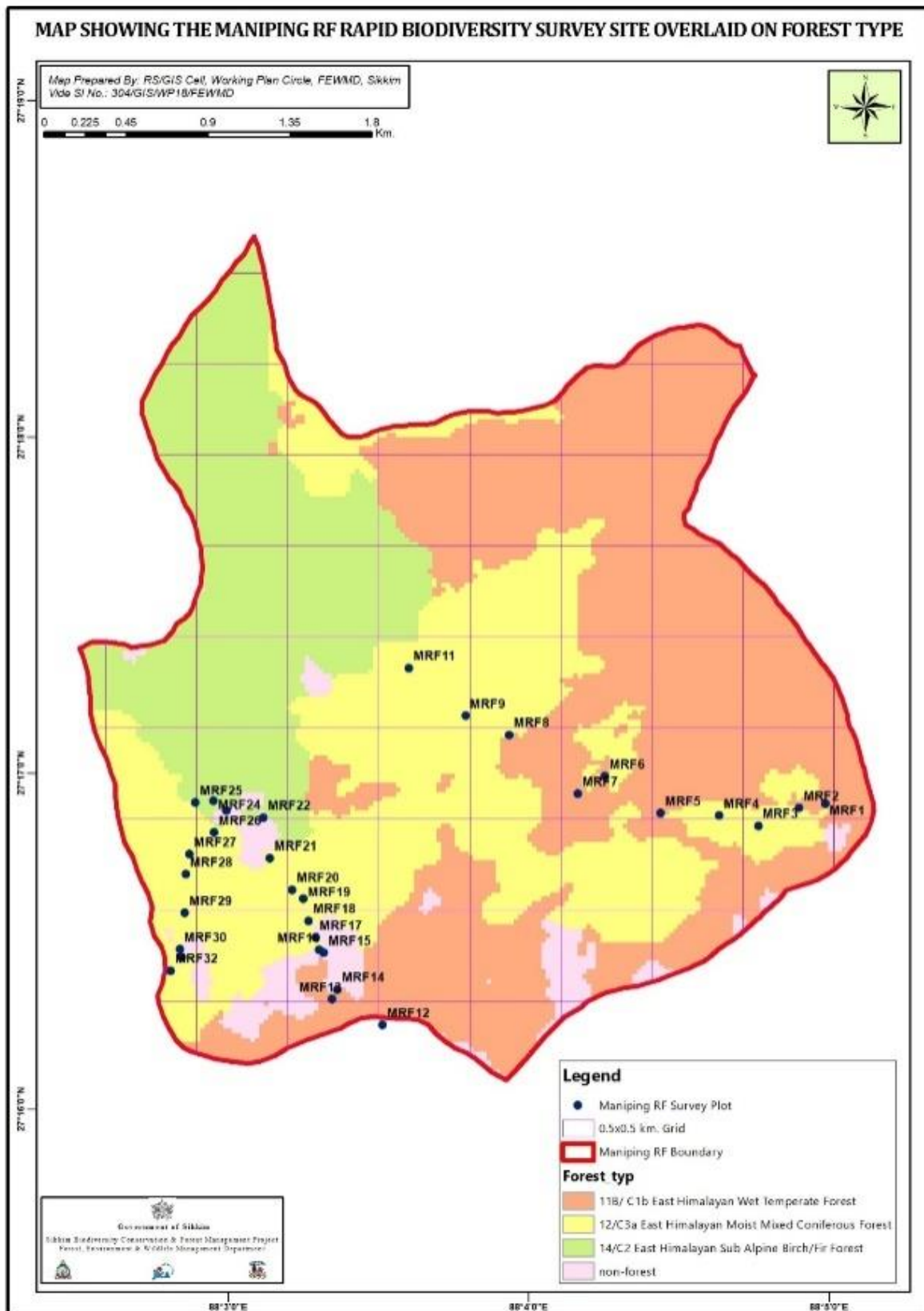


Figure 2c: Rapid biodiversity survey plots along Maniping RF covering forest types

| Table 22: Site Characteristics of Maniping Reserve Forest, West Sikkim. | | | | | | | |
|---|--------|-------------|--------------|---------------|-------------|--------------|------------------|
| Site Code | Range | Altitude(m) | Latitude (N) | Longitude (E) | Slope Angle | Slope Aspect | Canopy Cover (%) |
| MRF1 | Dentam | 2423 | 27°16'53.3" | 88°05'00.1" | 20 | N | 40 |
| MRF2 | Dentam | 2482 | 27°16'52.6" | 88°04'54.9" | 30 | N | 45 |
| MRF3 | Dentam | 2546 | 27°16'49.5" | 88°04'46.7" | 35 | N | 10 |
| MRF4 | Dentam | 2602 | 27°16'11.4" | 88°04'38.9" | 45 | NW | 80 |
| MRF5 | Dentam | 2648 | 27°16'51.9" | 88°04'27.2" | 25 | W | 50 |
| MRF6 | Dentam | 2707 | 27°16'58.6" | 88°04'16.1" | 20 | N | 55 |
| MRF7 | Dentam | 2718 | 27°16'55.5" | 88°04'10.7" | 45 | E | 30 |
| MRF8 | Dentam | 2716 | 27°17'06.1" | 88°03'57.1" | 15 | E | 10 |
| MRF9 | Dentam | 2705 | 27°17'09.6" | 88°03'48.4" | 50 | N | 70 |
| MRF10 | Dentam | 2763 | 27°16'53.3" | 88°05'00.1" | 55 | N | 10 |
| MRF11 | Dentam | 2805 | 27°17'18.2" | 88°03'37.2" | 30 | W | 60 |
| MRF12 | Dentam | 2225 | 27°16'14.5" | 88°03'31.3" | 20 | SW | 45 |
| MRF13 | Dentam | 2302 | 27°16'19.2" | 88°03'21.2" | 30 | N | 40 |
| MRF14 | Dentam | 2326 | 27°16'20.9" | 88°03'22.3" | 30 | N | 40 |
| MRF15 | Dentam | 2492 | 27°16'27.5" | 88°03'19.7" | 45 | N | 35 |
| MRF16 | Dentam | 2533 | 27°16'28.0" | 88°03'18.7" | 30 | N | 40 |
| MRF17 | Dentam | 2570 | 27°16'30.2" | 88°03'18.0" | 35 | N | 50 |
| MRF18 | Dentam | 2656 | 27°16'33.2" | 88°03'16.7" | 45 | S | 45 |
| MRF19 | Dentam | 2761 | 27°16'37.2" | 88°03'15.7" | 30 | N | 45 |
| MRF20 | Dentam | 2806 | 27°16'38.8" | 88°03'13.4" | 35 | NE | 55 |
| MRF21 | Dentam | 2944 | 27°16'44.5" | 88°03'09.1" | 35 | N | 60 |
| MRF22 | Dentam | 3017 | 27°16'51.3" | 88°03'07.8" | 45 | N | 40 |
| MRF23 | Dentam | 3015 | 27°16'53.0" | 88°03'00.4" | 35 | NE | 30 |
| MRF24 | Dentam | 3122 | 27°16'54.8" | 88°02'57.9" | 35 | NE | 5 |
| MRF25 | Dentam | 3150 | 27°16'54.5" | 88°02'54.3" | 45 | S | 5 |
| MRF26 | Dentam | 3066 | 27°16'49.1" | 88°02'57.9" | 35 | N | 35 |
| MRF27 | Dentam | 3039 | 27°16'45.3" | 88°02'53.0" | 35 | N | 10 |
| MRF28 | Dentam | 2972 | 27°16'41.7" | 88°02'52.2" | 45 | N | 5 |
| MRF29 | Dentam | 2861 | 27°16'34.8" | 88°02'52.0" | 30 | E | 10 |
| MRF30 | Dentam | 2781 | 27°16'28.3" | 88°02'50.9" | 45 | E | 10 |
| MRF31 | Dentam | 2749 | 27°16'26.9" | 88°02'51.3" | 45 | N | 5 |
| MRF32 | Dentam | 2732 | 27°16'24.5" | 88°02'49.0" | 40 | S | 5 |

NOTE: N, NORTH; NE, NORTH-EAST; NW, NORTH-WEST; W, WEST; E, EAST; SW, S, SOUTH; SW, SOUTH-WEST

RESULT

Maniping Reserve Forest is divided into 3 compartments and possesses 3 forest types viz., 11B/C1b East Himalayan Wet Temperate Forest (1800-2400 m asl), 12/C3a East Himalayan Moist Mixed Coniferous Forest (1500-3300m asl) & 14/C2 East Himalayan Sub Alpine Birch/Fir Forest (2900-3500m asl). A total of 72 floral species recorded, 67 genera belonging to 57 family members. Trees represented the highest number of species (21 species) belonging to 14 families with 17 genera. Herbs represented the second highest number of species (22 species) belonging to 17 families with 21 genera. Ferns and fern-allies represented 10 species with 10 genera belonging to 9 families. Climbers and epiphytes were represented by 10 species belonging to 10 genera and 9 families. Shrubs were 8 in number (8 genera and 7 families); and 1 bamboo species

was recorded in the entire area (Table 23 and Annexure 4).

| Habit | Species | Genus | Family |
|-------------------------------|-----------|-----------|-----------|
| Tree | 21 | 17 | 14 |
| Shrub | 8 | 8 | 7 |
| Herb | 22 | 21 | 17 |
| Fern and fern-allies | 10 | 10 | 9 |
| Climbers and Epiphytes | 10 | 10 | 9 |
| Bamboo | 1 | 1 | 1 |
| Total | 72 | 67 | 57 |

A total of 57 plant families containing 72 species of plants represented the floral diversity from the survey site. Family-wise analysis revealed that the maximum species recorded was from the family Ericaceae, Magnoliaceae, Rosaceae and Asteraceae with 4 species each which was followed by Polygonaceae and Urticaceae (3 species each), Aceraceae, Fagaceae, Symplocaceae, Berberidaceae, Araceae, Poaceae, Orchidaceae and Pteridaceae (2 species each). In case of herbs, Asteraceae represented the dominant family with 4 species viz. *Anaphalis margaritaceae*, *Artimesia wallichiana*, *Bidens pilosa* and *Eupatorium adenophorum* followed by 3 species in Polygonaceae viz. *Aconogonum molle*, *Persicaria capitata*, *Rumex nepalensis* were dominant in herb (Figure 25).

During the survey, a total of 32 plots were laid covering 0.32ha area, from which 21 trees, 8 shrubs, 22 herb species, 10 fern and fern-allies species, 10 climber/epiphyte species and 1 bamboo species were recorded. The forest is divided into 3 compartments and 3 forest types mainly 11B/C1b East Himalayan Wet Temperate Forest (1800-2400 m asl) which is closed evergreen forests with large girth tree trunks. Branches and tree bole are mainly

covered with mosses, ferns and other epiphytes. It is mainly dominated by *Quercus lamellosa*, *Magnolia campbellii*, *Symplocos glomerata*, *Symplocos lucida*, *Lithocarpus pachyphyllus* and *Alnus nepalensis*.

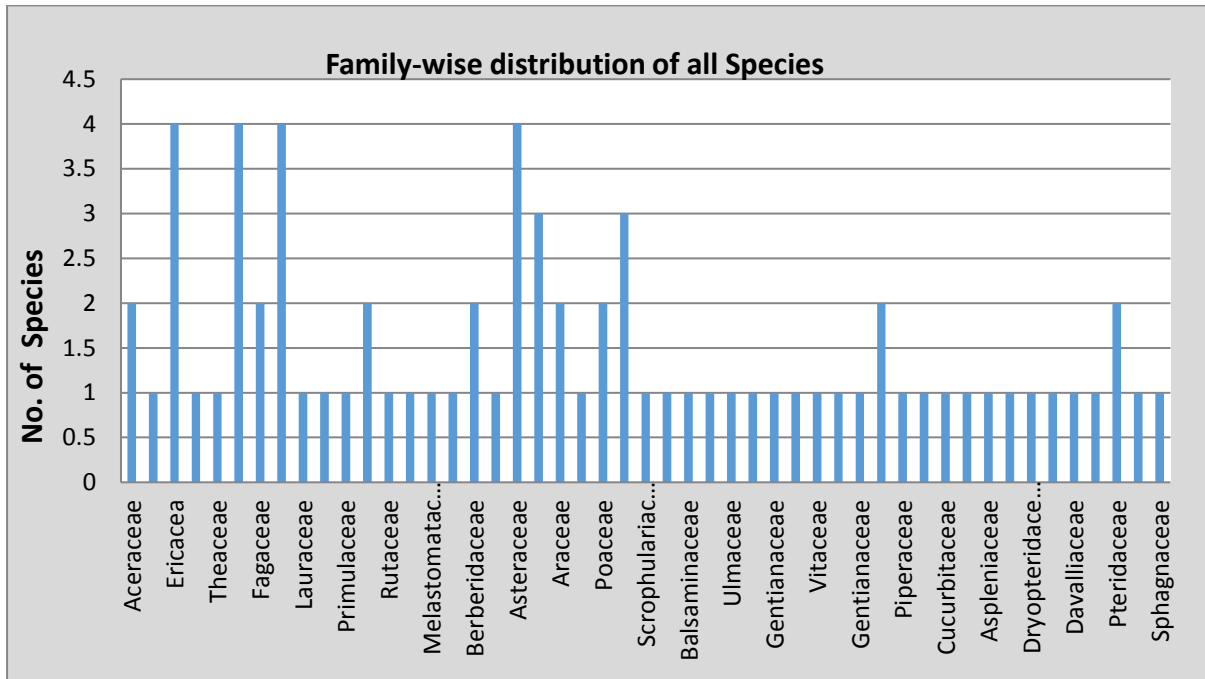


Figure 25: Family-wise distribution of plant species

Similarly, 12/C3a East Himalayan Moist Mixed Coniferous Forest (1500-3300m asl) occurs in warm and moist climatic conditions which are diverse and species-rich with many endemic species. It is dominated by *Lithocarpus pachyphyllus*, *Rhododendron arboreum*, *Cryptomeria japonica*, *Leucosceptrum cannum*, *Machilus edulis*, *Quercus lamellosa* and *Rhododendron arboreum*. Whereas, 14/C2 East Himalayan Sub Alpine Birch/Fir Forest (2900-3500m asl) usually finds the characteristics of stunted tree growth due to the extremely harsh conditions prevailing in this climatic condition. High fir forest is much in dominance between altitudes of 2900m and 3500m. Some broad-leaved species also accompany at the lower altitudes in this forest. Winter is usually below the freezing point accompanied by snowfalls. Similarly Birch forests join the fir forests at an elevation of above 3000m. The forests are open with the sporadic grassland. The winters are so severe in the region that vegetative growth virtually stops in the winters. It is characterized by rhododendron, birch and fir species.

Of the 21 large tree species recorded from the reserve forest (cumulatively 32 plots), the adult individuals of *Rhododendron hodgsonii* (262 ± 0.68 ind/ha) followed by *Lithocarpus pachyphyllus* (137 ± 0.26 ind/ha) and *Rhododendron arboreum* (100 ± 0.48 ind/ha) recorded the highest density; whereas in terms of total basal cover, *Lithocarpus pachyphyllus* (2289039.83 m²/ha), *Rhododendron hodgsonii* (1253856.95 m²/ha) and *Rhododendron arboreum* (533417.23 m²/ha) had the highest value (Table 24).

| Table 24: Availability of tree species in Maniping RF sampling path | | | | | |
|---|---------------------|---------------------------|---------------|-----------|-------|
| Species | Density (ind/ha)±SE | TBC (m ² / ha) | Frequency (%) | A/F ratio | IVI |
| <i>Acer campbellii</i> | 28.13±0.75 | 137243.91 | 12.50 | 0.18 | 8.74 |
| <i>Acer caudatum</i> | 25.00±0.88 | 210785.85 | 9.38 | 0.28 | 8.45 |
| <i>Alnus nepalensis</i> | 15.63±0.25 | 103884.70 | 12.50 | 0.10 | 6.98 |
| <i>Andromeda elliptica</i> | 34.38±0.17 | 114077.77 | 18.75 | 0.10 | 11.04 |
| <i>Cryptomeria japonica</i> | 9.38±0.50 | 95898.43 | 6.25 | 0.24 | 4.26 |
| <i>Eurya acuminata</i> | 12.50±0.33 | 107501.12 | 9.38 | 0.14 | 5.72 |
| <i>Leucosceptrum canum</i> | 65.63±0.82 | 318434.62 | 21.88 | 0.14 | 18.09 |
| <i>Lithocarpus pachyphyllus</i> | 137.50±0.37 | 2289039.83 | 46.88 | 0.06 | 60.54 |
| <i>Lyonia ovalifolia</i> | 31.25±0.21 | 207222.73 | 18.75 | 0.09 | 11.99 |
| <i>Michelia doltsopa</i> | 25.00±1.20 | 202333.75 | 9.38 | 0.28 | 8.33 |
| <i>Machilus edulis</i> | 12.50±0.33 | 149520.91 | 9.38 | 0.14 | 6.30 |
| <i>Magnolia campbellii</i> | 21.88±1.33 | 302481.85 | 9.38 | 0.25 | 9.38 |
| <i>Myrica esculenta</i> | 18.75±0.20 | 155909.95 | 15.63 | 0.08 | 9.00 |
| <i>Quercus lamellosa</i> | 12.50±0.33 | 384740.75 | 9.38 | 0.14 | 9.54 |
| <i>Rapanea capitellata</i> | 15.63±0.25 | 157926.46 | 12.50 | 0.10 | 7.72 |
| <i>Rhododendron arboreum</i> | 100.00±3.01 | 533417.23 | 15.63 | 0.41 | 22.67 |
| <i>Rhododendron falconeri</i> | 37.50±0.63 | 68067.04 | 18.75 | 0.11 | 10.73 |
| <i>Rhododendron hodgsonii</i> | 262.50±3.27 | 1253856.95 | 21.88 | 0.55 | 51.48 |
| <i>Symplocos glomerata</i> | 34.38±0.48 | 173753.00 | 12.50 | 0.22 | 9.90 |
| <i>Symplocos lucida</i> | 40.63±0.95 | 225632.55 | 12.50 | 0.26 | 11.26 |
| <i>Zanthoxylum acanthopodium</i> | 18.75±0.20 | 73907.75 | 15.63 | 0.08 | 7.87 |

SE: Standard error; TBC: Total basal cover; A/F Ratio: Abundance to frequency ratio; IVI: Important value index

The highest IVI value was recorded for *Lithocarpus pachyphyllus* (60.54) followed by *Rhododendron hodgsonii* (51.48), *Rhododendron arboreum* (22.67), *Leucosceptrum canum* (18.09), *Lyonia ovalifolia* (11.99) and *Symplocos lucida* (11.26; Table 24). The highest frequency of occurrence was observed for *Lithocarpus pachyphyllus* (46.88%), *Leucosceptrum canum* (21.88%) and *Rhododendron hodgsonii* (21.88%; Figure 26).

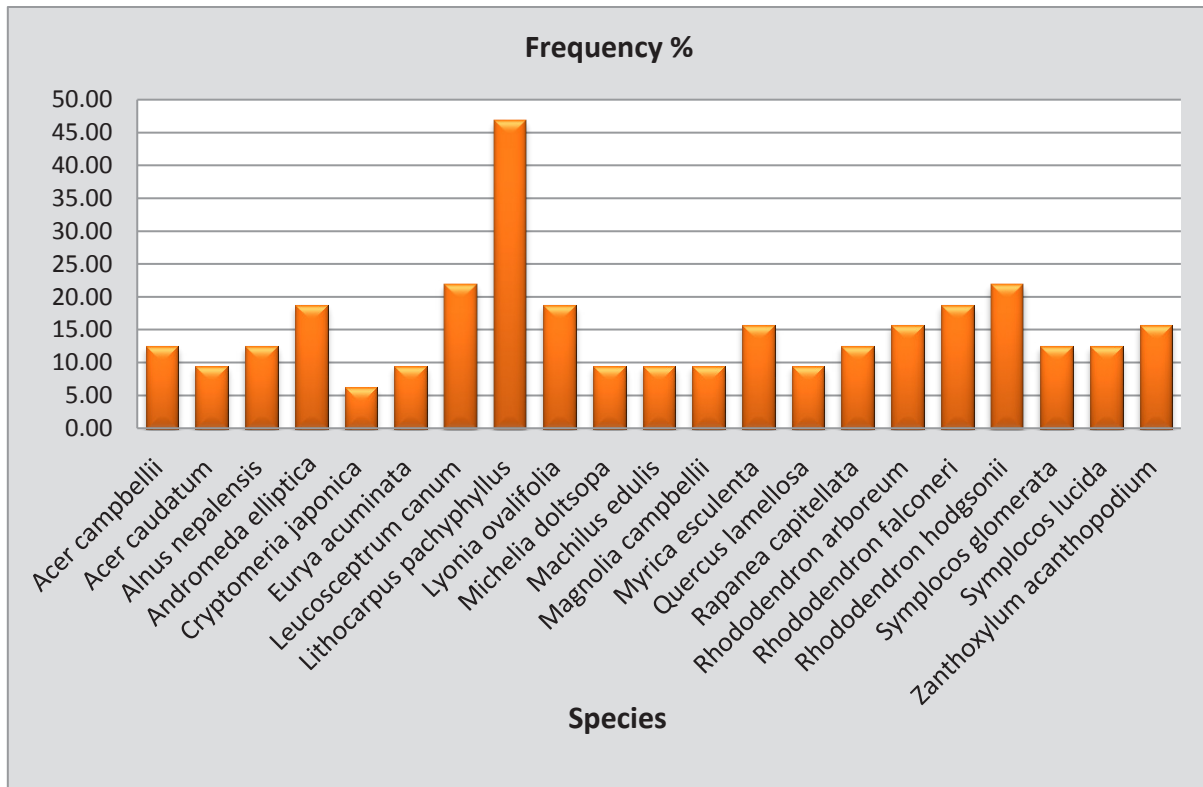


Figure 26: Frequency of tree species (adult individuals) along Maniping RF sampling path

The highest sapling density in the forest was evidenced for *Rhododendron falconeri* (34.38 ± 0.25 ind/ha) followed by *Symplocos lucida* (25.00 ± 1.20 ind/ha), *Picea spinulosa* (25.00 ± 1.20 ind/ha) and *Viburnum erubescens* (25.00 ± 0.88 ind/ha); while the lowest sapling density was observed for *Symplocos glomerata* (9.38 ± 0.50 ind/ha) (Table 24). Similarly, the highest seedling density was found in *Symplocos lucida* (65.63 ± 1.34 ind/ha), *Symplocos glomerata* (59.38 ± 0.98) and *Rhododendron arboreum* (46.88 ± 0.62); while the lowest was observed in *Abies densa* (9.38 ± 0.50 ind/ha) and *Mahonia napaulensis* (21.88 ± 0.33 ind/ha) (Table 25). The maximum frequency of occurrence for sapling was observed for *Mahonia napaulensis* (15.63%; Figure 27); whereas, the maximum seedling frequency was evidenced for *Viburnum erubescens* (21.88%) and *Lyonia ovalifolia* (21.88%; Figure 28).

| Table 25: Availability of sapling and seedling species in Maniping RF sampling path | | |
|---|-----------------------|-----------------------|
| Species | Sapling | Seedling |
| | Density (ind/ha) ± SE | Density (ind/ha) ± SE |
| <i>Abies densa</i> | 12.50±0.33 | 9.38±0.50 |
| <i>Acer campbellii</i> | 12.50±0.33 | - |
| <i>Alnus nepalensis</i> | 12.50±0.33 | 40.63±1.17 |
| <i>Cryptomeria japonica</i> | 15.63±0.33 | - |
| <i>Daphne cannabina</i> | - | 34.38±0.17 |
| <i>Eurya acuminata</i> | - | 28.13±0.37 |
| <i>Ilex sikkimensis</i> | 15.63±0.33 | - |
| <i>Leucosceptrum canum</i> | 15.63±0.33 | - |
| <i>Lithocarpus pachyphyllus</i> | 18.75±0.58 | - |
| <i>Lyonia ovalifolia</i> | 25.00±0.41 | 25.00±0.14 |
| <i>Machilus edulis</i> | 12.5±0.33 | |
| <i>Magnolia campbellii</i> | 15.63±0.33 | 21.88±0.48 |
| <i>Mahonia napaulensis</i> | 21.88±0.24 | 21.88±0.33 |
| <i>Michelia doltsopa</i> | 18.75±0.29 | - |
| <i>Myrica esculenta</i> | 12.5±0.33 | - |
| <i>Picea spinulosa</i> | 25.00±1.20 | - |
| <i>Quercus lamellosa</i> | 15.63±0.25 | - |
| <i>Rapanea capitellata</i> | 15.63±0.25 | - |
| <i>Rhododendron arboreum</i> | 15.63±0.50 | 46.88±0.62 |
| <i>Rhododendron falconeri</i> | 34.38±0.25 | - |
| <i>Rhododendron hodgsonii</i> | 15.63±0.33 | - |
| <i>Symplocos glomerata</i> | 9.38±0.50 | 59.38±0.98 |
| <i>Symplocos lucida</i> | 25.00±1.20 | 65.63±1.34 |
| <i>Viburnum erubescens</i> | 25.00±0.88 | 37.5±0.29 |
| <i>Zanthoxylum acanthopodium</i> | 15.63±0.33 | - |

SE: Standard error

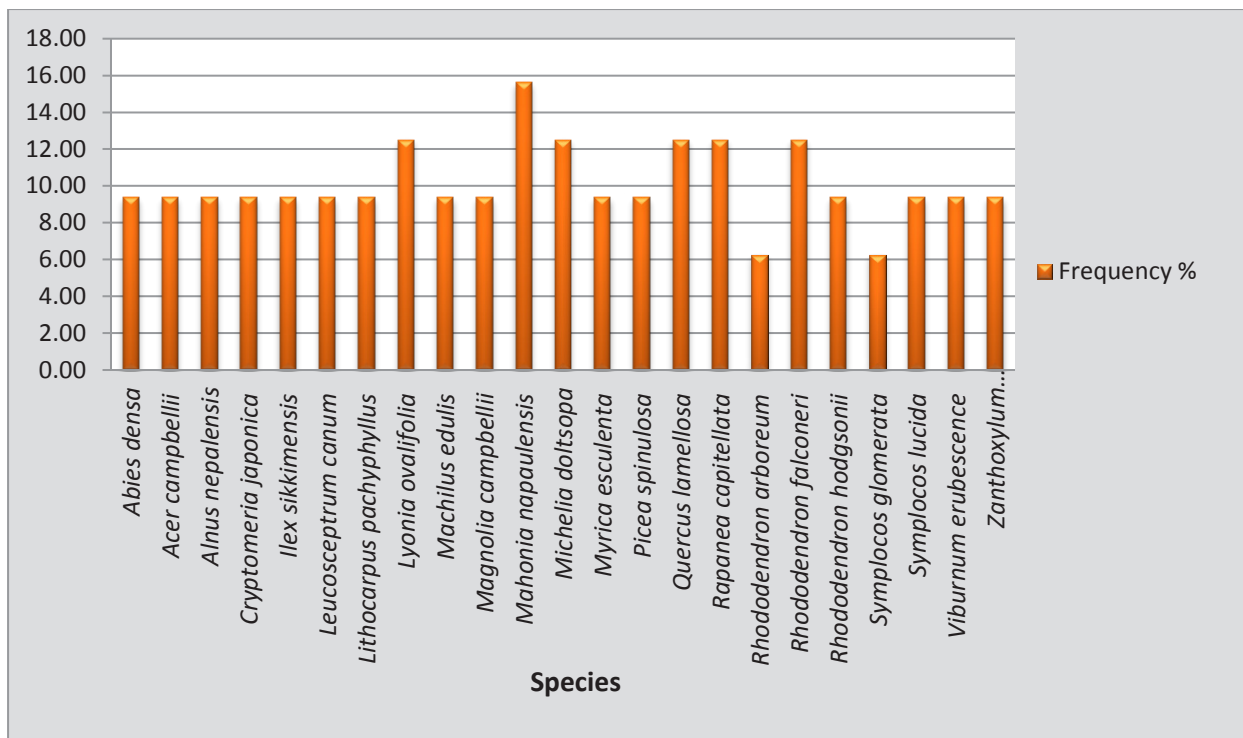


Figure 27: Percentage of saplings encountered along...

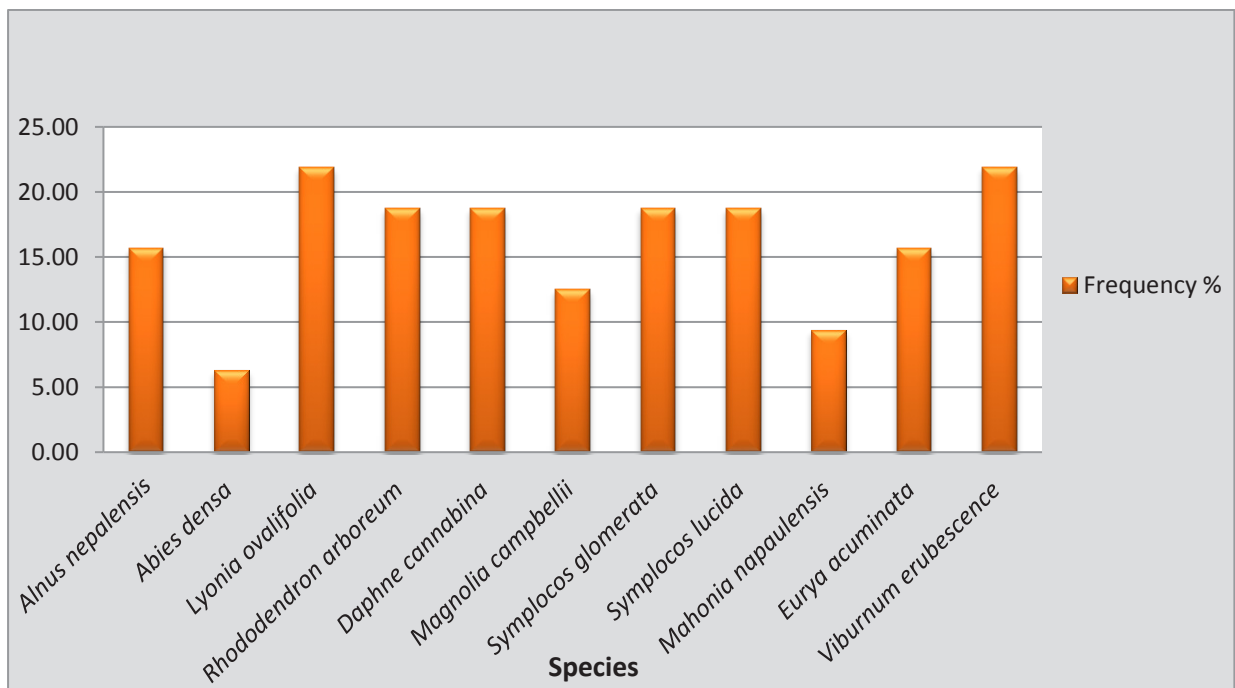


Figure 28: Percentage of seedling encountered along...

Based on diameter class, the tree was measured under different girth class for precise determination of stand structure with the gradient of 10 cm rise starting from 30 cm at gbh. The intervals started from 20-30 cm and ended at 141-150 cm at gbh. Dominant species as

well as a few major tree species of the study site was measured to understand the community structure.

Based on the diameter class, the individuals falling in B diameter class had the highest density (275 ind/ha) followed by C (131.25 ind/ha; **Figure 29**). While the H diameter class had the lowest density (12.5 ind/ha; **Figure 29**).

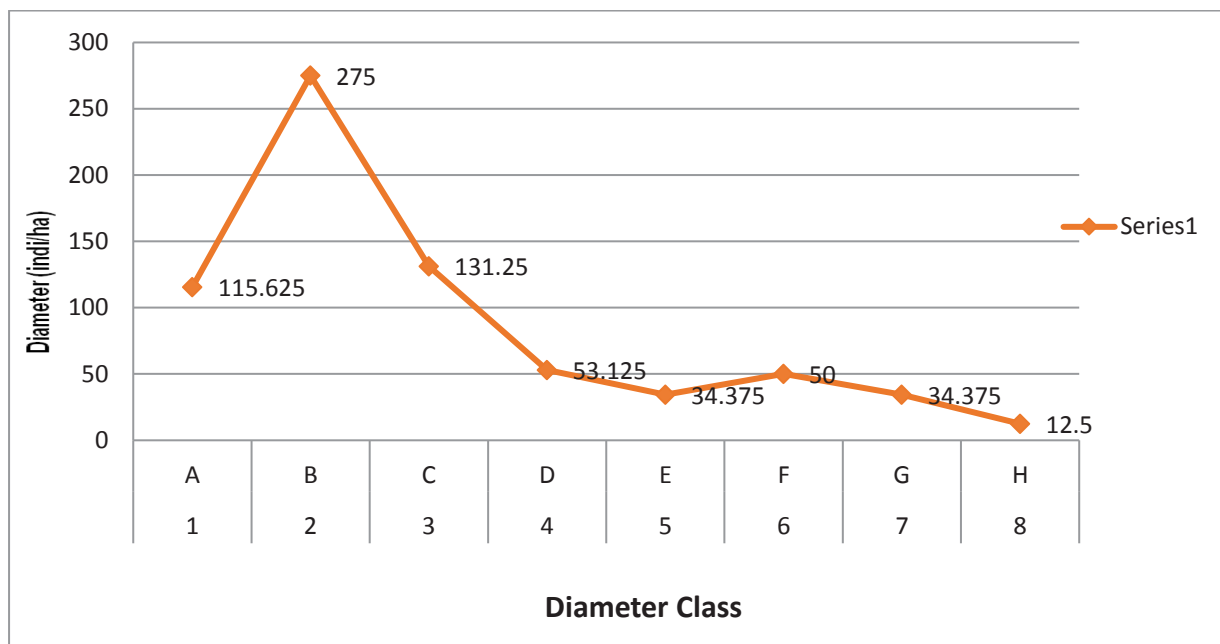


Figure 29: Class-wise availability of tree species in the sampling site

Among the tree species, *Quercus lamellosa* recorded the highest diameter in the diameter class 12 (1 no. of species), followed by *Lithocarpus pachyphyllus* falling under diameter class 9 (1 no. of species). While *Andromeda elliptica* (5 no. of species), *Symplocos glomerata* (4 no. of species), *Zanthoxylum acanthopodium* (3 no. of species), *Rhododendron arboreum*, *Rhododendron falconeri* and *Leucosceptrum canum* had (2 no. of species each) were recorded the lowest diameter in diameter class 1 (**Figure 29**). While, *Rhododendron hodgsonii* was recorded with maximum number species in girth class 2 (35 no. of species) followed by *Rhododendron hodgsonii* in girth class 5 (17 no. of species), *Lithocarpus pachyphyllus* in girth class 6 (12 no. of species) and *Symplocos lucida* in girth class 2 (10 no. of species; **Figure 29**). Similarly, diameter class distribution for some of the dominant species in Maniping Reserve Forest is depicted in **Figure 30**, which reveals that, for no species, individuals falling in all the diameter class was recorded from the study sites.

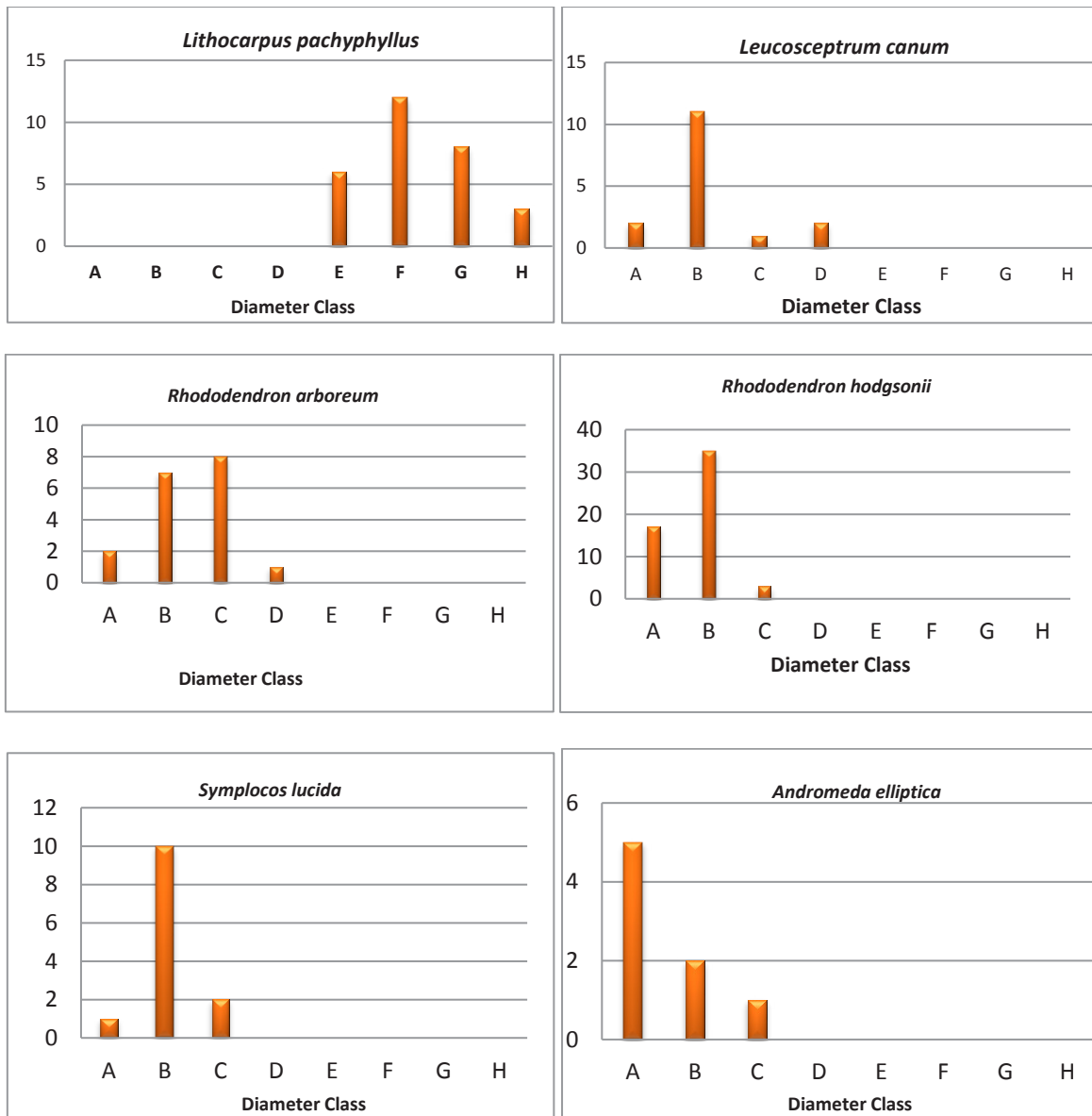


Figure 30: Diameter class distributions for some of the dominant tree species in Maniping RF sampling path

A total of 6 species of shrubs belonging to 5 genera and 5 families were recorded. The highest percent cover was recorded for *Viburnum erubescens* (21.1%) followed by the *Mahonia sikkimensis* (16%), *Osbeckia stellata* (12.3%) and *Rubus ellipticus* (7.8%; **Figure 31**). While the lowest percentage was recorded for *Ilex sikkimensis* (0.7%) followed by *Berberis angulossa* (2.5%; **Figure 31**).

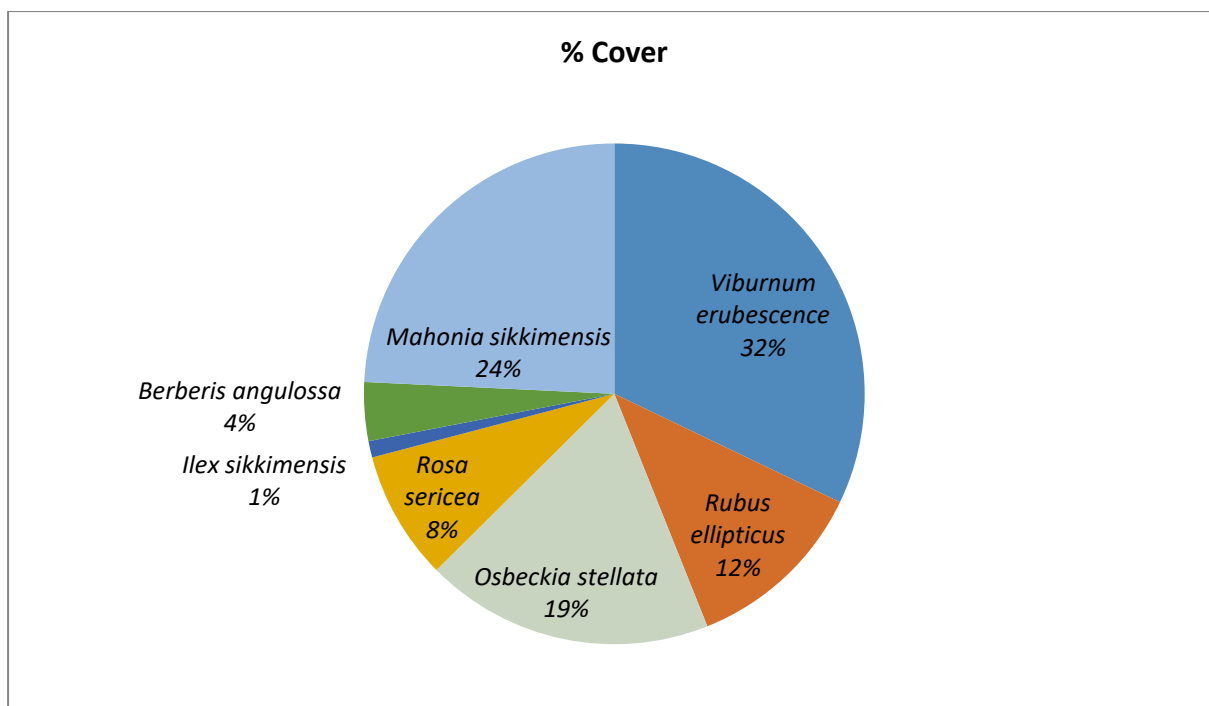


Figure 31: % cover of shrubs in Maniping RF sampling path

Similarly, a total of 21 species of herbs with 20 genera and 15 families were recorded. The highest percentage cover was recorded for *Artimesia wallichiana* (26%) followed by *Heracleum wallichii* (22%), *Cynodon dactylon* (20.33%), *Oxalis corniculata* (15.50%) and *Bidens pilosa* (14.60%; **Figure 32**); while the lowest percentage was recorded for *Pilea scripta* (2.00%), *Pilea umbrosa* (3.33%), *Anaphalis margaritaceae* (3.67%), *Viola bicolor* (4.80%) and *Impatiens urticifolia* (4.00%; **Figure 32**). If we go according to the family-wise composition, the highest number of taxa was recorded for Asteraceae (4) followed by Polygonaceae (3) and Urticaceae (3; **Figure 33**). Apart from the above species, the commonly found herbs are represented by *Carex* sp., *Aconogonum molle*, *Artimesia wallichiana*, *Cynodon dactylon*, *Heracleum wallichii*, *Bidens pilosa*, *Fragaria nubicola* and *Solanum khasianum*, etc.

However, many species of fern and fern-allies such as *Selaginella monospora*, *Pteris wallichiana*, *Diplazium dilatatum*, *Dryopteris redactopinnata*, *Lycopodium clavatum*, *Nephrolepis cordifolia* and *Asplenium ensiforme* cover the forest floor in clusters and some grow as epiphytes as well. The trees also support epiphytic orchids and climbers of various species like *Crawfurdia speciosa*, *Cissus elongata*, *Piper boehmeriifolium*, *Rubia manjith* and *Clematis buchananiana* and *Dendrobium chrysanthum*.

FAUNA

During the trail sampling, a total of 7 species of mammals and 18 bird species were recorded along Maniping trail (**Tables 26 & 27**). Amongst the mammalian species, Assamese Macaque, Himalayan Serow has been assessed as near threatened by the IUCN whereas Himalayan black bear as Vulnerable.



Photo 13: Scats of Dhole

| S.No | Common Name | Zoological Name | Local Name | Evidences ¹ | IUCN Status ² |
|------|-----------------------------------|-----------------------------------|-------------|------------------------|--------------------------|
| 1 | Orange-bellied himalayan squirrel | <i>Dremomys lokriah</i> | Lothurke | S | LC |
| 2 | Rhesus macaque | <i>Macaca mulatta</i> | Badhar | S | LC |
| 3 | Barking deer | <i>Muntiacus muntjak</i> | Darey Mirga | C | LC |
| 4 | Asian palm civet | <i>Paradoxurus hermaphroditus</i> | | Sc | LC |
| 5 | Leopard cat | <i>Prionailurus bengalensis</i> | Ningalo | Pm | LC |
| 6 | Wild pig | <i>Sus scrofa</i> | Bodel | DS | LC |
| 7 | Himalayan black bear | <i>Ursus thibetanus</i> | Bhaloo | Ds, Fs | LC |
| 8 | Red fox | <i>Vulpes vulpes</i> | Sheyal | Sc | LC |

¹C: Call, **DS**: Digging sign, **FS**: Foraging sign, **PM**: Pug mark, **S**: Sighting ²LC: Least concern

| Table 27: Checklist of bird species encountered along Maniping RF transect | | | | | | |
|--|--------------------------------|---------------------------------|------------|----------------|------------------------|--------------------------|
| S.No | Common Name | Scientific Name | Local Name | Family | Evidences ¹ | IUCN Status ² |
| 1 | Common Myna | <i>Acridotheres tristis</i> | Ruppi | Sturnidae | S | LC |
| 2 | Hoary Barwing | <i>Actinodura nepalensis</i> | | Timaliidae | S | LC |
| 3 | Rufous-fronted Tit | <i>Aegithalos louschistos</i> | Fista | Paridae | S | LC |
| 4 | Nepal Sunbird | <i>Aethopyga nepalensis</i> | Kalobalchi | Nectariniidae | S | LC |
| 5 | Common Hill Partridge | <i>Arborophila torqueola</i> | Peura | Phasinidae | S | LC |
| 6 | Common Green Magpie | <i>Cissa chinensis</i> | | Corvidae | S | LC |
| 7 | Jungle Crow | <i>Corvus macrorhincus</i> | Khag | Corvidae | S | LC |
| 8 | Grey Headed Canary Flycatcher | <i>Culicica paceylonensis</i> | | Muscicapidae | S | LC |
| 9 | Ashy Drongo | <i>Dicrurus leucophaeus</i> | Chibey | Dicaeidae | S | LC |
| 10 | Verditer Flycatcher | <i>Eumyias thalassinus</i> | Hareney | Muscicapidae | S | LC |
| 11 | White Crested Laughing Thrush | <i>Garrulax leucolophus</i> | | Leiothrichidae | S | LC |
| 12 | Striated Laughing Thrush | <i>Garrulax striatus</i> | Kolkoley | Turdidae | S | LC |
| 13 | Black Bulbull | <i>Hypsipetes leucocephalus</i> | Jureli | Leiothrichidae | S | LC |
| 14 | Kalij Pheasant | <i>Lophura leucomelanos</i> | Kalij | Phasianidae | S | LC |
| 15 | Great Barbet | <i>Megalaim avirens</i> | Neual | Megalaimidae | S | LC |
| 16 | Blue Whistling Laughing Thrush | <i>Myiophonus caeruleus</i> | | Muscicapidae | S | LC |
| 17 | House Sparrow | <i>Passer domesticus</i> | Bhangera | Passeridae | S | LC |
| 18 | Red Vented Bulbull | <i>Pycnonotus cafer</i> | Jureli | Pycnonotidae | S | LC |
| 19 | Straited Bulbull | <i>Pycnonotus striatus</i> | Jureli | Pycnonotidae | S | LC |
| 20 | Oriental Turtle Dove | <i>Streptopelia orientalis</i> | Dhukur | Columbidae | S | LC |
| 21 | Whiskered Yuhina | <i>Yuhina flavicollis</i> | Megma | Timaliidae | S | LC |

¹S: Sighting; LC: Least concern



Photo 14: Kalij Pheasant

DISCUSSION

According to Bajpai *et al.* (2012), the mosaics of species distribution in any forest are governed by various environmental factors. Bliss (1963), Douglas & Bliss (1977) and Billings (1973) have reported that vegetation of any place is the outcome interaction of many factors like meso-topographic gradients, the elevation, soil, species composition and biotic interferences. It is also reported that the regional patterns of species richness are consequences of many interacting factors, such as plant productivity, competition, geographical area, historical or evolutionary development, regional species dynamics, regional species pool, environmental variables and human activity (Woodward 1988; Palmer 1991; Eriksson 1996; Zobel 1997; Criddle *et al.* 2003). The values of vegetation parameters obtained for most of the sites in the present study fall within a comparable range of values reported for Western Himalaya (Kala & Uniyal 1999).

Maniping Reserve Forest has been categorised into three forest types viz., 11B/C1b East Himalayan Wet Temperate Forest, 12/C3a East Himalayan Moist Mixed Coniferous Forest, 14/C2 East Himalayan Sub Alpine Birch/Fir Forest. The RF is divided into three compartments. In comparison, compartment 1 possessed highest forest density. The entire RF falls under Singalila range in West Sikkim.

The present study shows that the RF is dominated by Rosaceae (4 species) followed by Ericaceae (4 species), Magnoliaceae (4 species), Asteraceae (4 species), Polygonaceae (3 species), Urticaceae (3 species), Aceraceae (2 species), Fagaceae (2 species), Symplocaceae (2 species), Berberidaceae (2 species), Araceae (2 species), Poaceae (2 species) and Orchidaceae (2 Species) in the entire plots. Rosaceae, Ericaceae, Magnoliaceae and Asteraceae are major dominant family in present study area. The family included several species belonging to the genus *Rosa*, *Prunus*, *Rubus*, *Fragaria*, *Rhododendron*, *Anaphalis*, *Artemisia* etc.

The tree density was recorded highest in *Rhododendron hodgsonii* followed by *Lithocarpus pachyphyllus*, *Rhododendron arboreum* and *Leucosceptrum canum*. Whereas in the seedling, the highest density was recorded in *Symplocos lucida* followed by *Symplocos glomerata*, *Alnus nepalensis*, *Viburnum erubescens*, *Daphne cannabina*, *Eurya acuminata* and *Lyonia ovalifolia*. In saplings, highest density was recorded in *Rhododendron falconeri*, *Symplocos lucida*, *Viburnum erubescens*, *Lyonia ovalifolia*, *Picea spinulosa*, *Lithocarpus pachyphyllus* and *Michelia doltsopa*.



Photo 15: Inventorying the plants

The highest frequency was recorded in *Mahonia napaulensis*, *Michelia doltsopa*, *Quercus lamellosa*, *Rapanea capitellata*, *Rhododendron falconeri* and *Lyonia ovalifolia*. While, in the seedling highest frequency was recorded in *Lyonia ovalifolia*, *Viburnum erubescens*, *Rhododendron arboreum*, *Daphne cannabina*, *Symplocos glomerata*, *Symplocos lucida* and *Alnus nepalensis*. In sapling the highest frequency was recorded in

Lyonia ovalifolia, *Viburnum erubescens*, *Rhododendron arboreum*, *Daphne cannabina*, *Symplocos glomerata*, *Symplocos lucida*, *Eurya acuminata* and *Alnus nepalensis*.

The Important value index (IVI) of dominant tree species in Maniping Reserve Forest was recorded highest in *Lithocarpus pachyphyllus* (60.54) followed by *Rhododendron hodgsonii* (51.48), *Rhododendron arboreum* (22.67), *Leucosceptrum canum* (18.09), *Lyonia ovalifolia* (11.99), *Symplocos lucida* (11.26) and *Andromeda elliptica* (11.04). When further analyzed with girth classes, the intervals started from 31cm to 40 cm and ended at 141-150 cm at ghb. The dominant species as well as a few major tree species of the study site was measured to understand the community structure. Among the tree species *Lithocarpus pachyphyllus*, *Machilus edulis* and *Quercus lamellosa* followed almost a normal distribution curve with increasing the girth classes suggesting stable population. In case of *Rhododendron arboreum*, *Rhododendron hodgsonii*, *Symplocos glomerata*, *Symplocos lucida*, and *Acer caudatum* there is larger proportion of small girth classes to moderate girth classes than fairly big trees. This study suggested that the population of these trees is more stable and is capable of regenerating to mature trees under favorable conditions.

The highest percent cover of shrubs/scrub species according to diminishing order was recorded in *Ilex sikkimensis*, *Berberis angulosa* and *Daphne cannabina* in the entire sampling plots. While the highest shrub percent cover was recorded in *Viburnum erubescens* (21.2), *Mahonia sikkimensis* (16), *Osbeckia stellata* (12.3) and *Rubus ellipticus* (7.8). The highest herb percent cover was recorded in *Carex sp.* (46.6), *Cynodon dactylon* (12.2), *Artimesia wallichiana* (10.6), *Fragaria nubicola* (9.5), *Bidens pilosa* (7.3) and *Heracleum wallichii* (6.8). While the lowest herb percent cover was recorded in *Pilea scripta* (0.6), *Persicaria capitata* (0.9), *Pilea umbrosa* (1), *Rumex nepalensis* (1), *Anaphalis margaritacea* (1.1), *Hemiphragma heterophyllum* (2.2), *Gerardiana diversifolia* (2.3), *Viola bicolor* (2.4) and *Eupatorium adenophorum* (2.9). Similarly, in the family-wise species composition the maximum family of herbs species were recorded Asteraceae (4 species), Urticaceae (3 species) and Polygonaceae (3 species), respectively. The highest family under Asteraceae included *Anaphalis margaritaceae*, *Artimesia wallichiana*, *Bidens pilosa* and *Eupatorium adenophorum*. Under family Urticaceae following species *Gerardiana diversifolia*, *Pilea umbrosa* and *Urtica dioica* was included. While under family Polygonaceae *Aconogonum molle*, *Persicaria capitata* and *Rumex nepalensis* was present. Apart from these plant species, one bamboo species *Yushania maling* (locally called as “Maling”) was sporadically distributed in Maniping Reserve Forest trekking trail. The bamboo is used in house

construction and for matting. When growing vigorously, the bamboo can be used for weaving baskets or making fencing, more usually though the growth is smaller and is used for making brushes and straws.

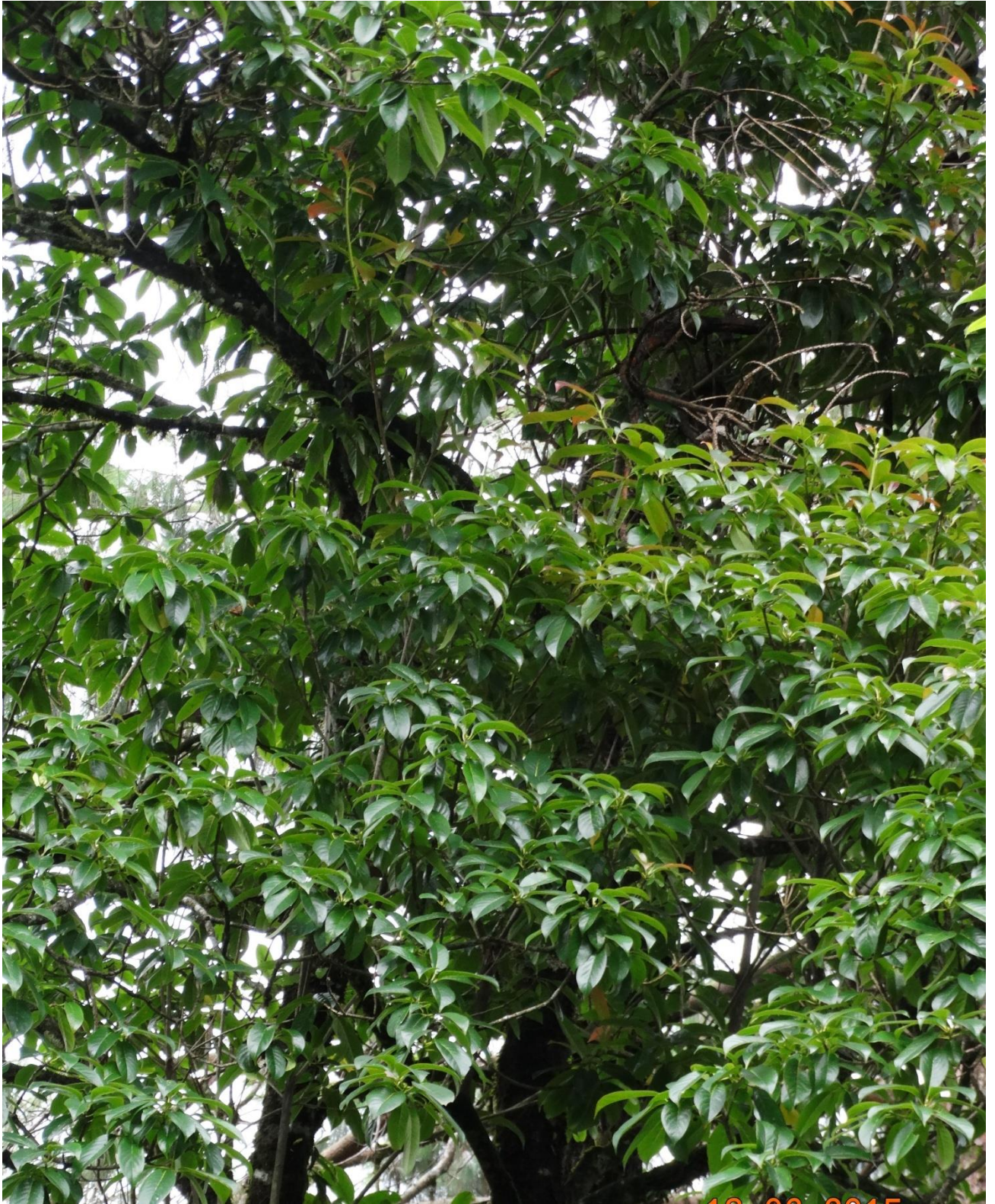
CONCLUSION

A total of 32 sampling plots were laid in the Maniping Reserve Forest. The study site is rich in floral diversity. Through the indirect evidences such as scats, grubbing, toe marks, pellets, etc it can be assumed that the RF supports considerable number of faunal species. At the lower elevation of the RF at temperate zone, direct sighting of kalij pheasant (male) was made. The forest is free from anthropogenic disturbances and grazing. The RF varies from the temperate zone to alpine meadow. The temperate zone is dominated by *Oak* species, *Acer* species, *Rhododendron* species, etc and the forest floor is mainly dominated by *Heracleum wallichii*, *Cynodon dactylon*, *Bidens pilosa*, etc. While the alpine meadows were mainly dominated by *Berberis angulossa*, *Ilex sikkimensis*, *Carex* sp., etc.

The RF lies in the Singalila range adjacent to the Barsey Rhododendron Sanctuary and shares the international border with Nepal in the North. Due to international border with Nepal, SSB camps are stationed at numerous places. ChiwaBhanjyang is the main entry and exit point for both the countries and which has helped the citizens of both the countries to access either side of the territories. Nepal Government has already constructed the road up to ChiwaBhanjyang in Nepal part and wants to link the road with Sikkim, the State of India so that there will be a better bilateral relations between both the countries.

Photo 16: Temperate forest in Maniping RF





Nyssa javanica (Lek Chilauney)



Blue-fronted redstart (Female)

Quantitative Analysis of Vegetation and Assessment of Faunal Diversity of Nambu Reserve Forest in West Sikkim, India

*Sanjyoti Subba, Sanchi Subba & Sumitra Nepal

ABSTRACT

A total of 128 species were recorded of which 52 herb species followed by tree 44 species, 10 shrubs/scrub, 13 climbers and 9 ferns and fern-allies. The area harbour over 15 orchid species. Life-form spectrum provides an unambiguous picture, the hemicryptophytes was the highest plant life-form as compared to other life forms. The value for the highest species diversity index (H) was observed as 3.22 for tree followed by sapling (2.52) and seedling (2.51). The species diversity index value generally between 1.5 and 3.5 in most ecological studies. The highest species richness was recorded for tree (35.82) followed by sapling (20.82) and seedling (18.82) as compared with species evenness of tree (0.90) followed by seedling (0.85) sapling (0.83). The highest adult individuals per hectare were recorded for *Symplocos lucida* (160.00 Ind/ha) followed by *Quercus lamellosa* (155.00 Ind/ha), *Castanopsis hystrix* (150.00 Ind/ha), and *Symplocos glomerata* (130.00Ind/ha). Quantitative evaluation and analysis of the community structure are important for accurate assessment of biodiversity. The present study area revealed the analysis of vegetation patterns and plant species diversity of Nambu reserve forest in west Sikkim.

Keywords: Quantitative analysis, Nambu Reserve Forest, Species diversity, Biodiversity Conservation

INTRODUCTION

The global environment has been changing and the living organisms have adapted continuously to these changes. Natural landscapes have constantly changed and the new habitats have been created. This process has resulted in evolution of new species and extinction of many others species by Chettri (2010). Biodiversity represents the variability in nature and relates to the differences within and between species and their surroundings, i.e. ecosystems.

Many studies confirmed that forests have an important role in maintaining the productivity of the environment; trees provide food for animals, serve as a standing cover to

protect the land from wind and water erosion, stabilizing the water cycle, facilitate the process of evaporation, and keep the soil porous; they are also used for construction as well as for tools, furniture, fuel, medicine, grass, and herb and for forage and provide edible fruits by Kuma and Shibru (2015). Forest structure is a key to understanding forest ecosystem and the tree plays a significant role in the forest. Tree species diversity that influences the forests are climate, stand structure, species composition, family-wise species composition and geomorphology.

Many workers have studied tree species diversity in northeast by Nath *et al.* (2005), Bhuyan *et al.* (2003), Das & Das (2005); Kumar *et al.* (2006) and Devi and Das (2012). In Sikkim, several workers have studied and the inventory of tree species by Rai & Rai (1993), Singh & Chauhan (1998), Cowan & Cowan (1929). Quantitative evaluation and analysis of the community structure are important for accurate assessment of biodiversity. Many studies have been conducted on plant species diversity in different forest types of Sikkim Himalayan Region (Subba *et al.* 2015; Subba *et al.* 2016; Subba *et al.* 2017; Subba *et al.* 2018 and Subba & Lachungpa 2016).

The rapid biodiversity survey of quantitative data that provides information on species diversity, richness and evenness will represent an important tool for the conservation of biodiversity. Information from this quantitative inventory will provide a valuable reference for forest assessment and forest management plan.

STUDY AREA

Nambu reserve forest is located in the west district between latitude 27°17'16.0"N – 27°18'14.0"N and longitude 88°09'00.9"E – 88°09'55.8"E and its elevation ranges from 1964m to 2191m ASL, sharing its border with Lunggang RF (north), Bangtim RF (south), Cidang RF (west) and Sengbeng RF (east) over the Nambu khola in the west Sikkim. This reserve forests are very rich in floral and faunal diversity. The reserve forest shows the aspects of E, N and NE with the slope angle falling between 5 degree and 70 degree inclination (**Figure 34, Table 28 and Annexure 5**).

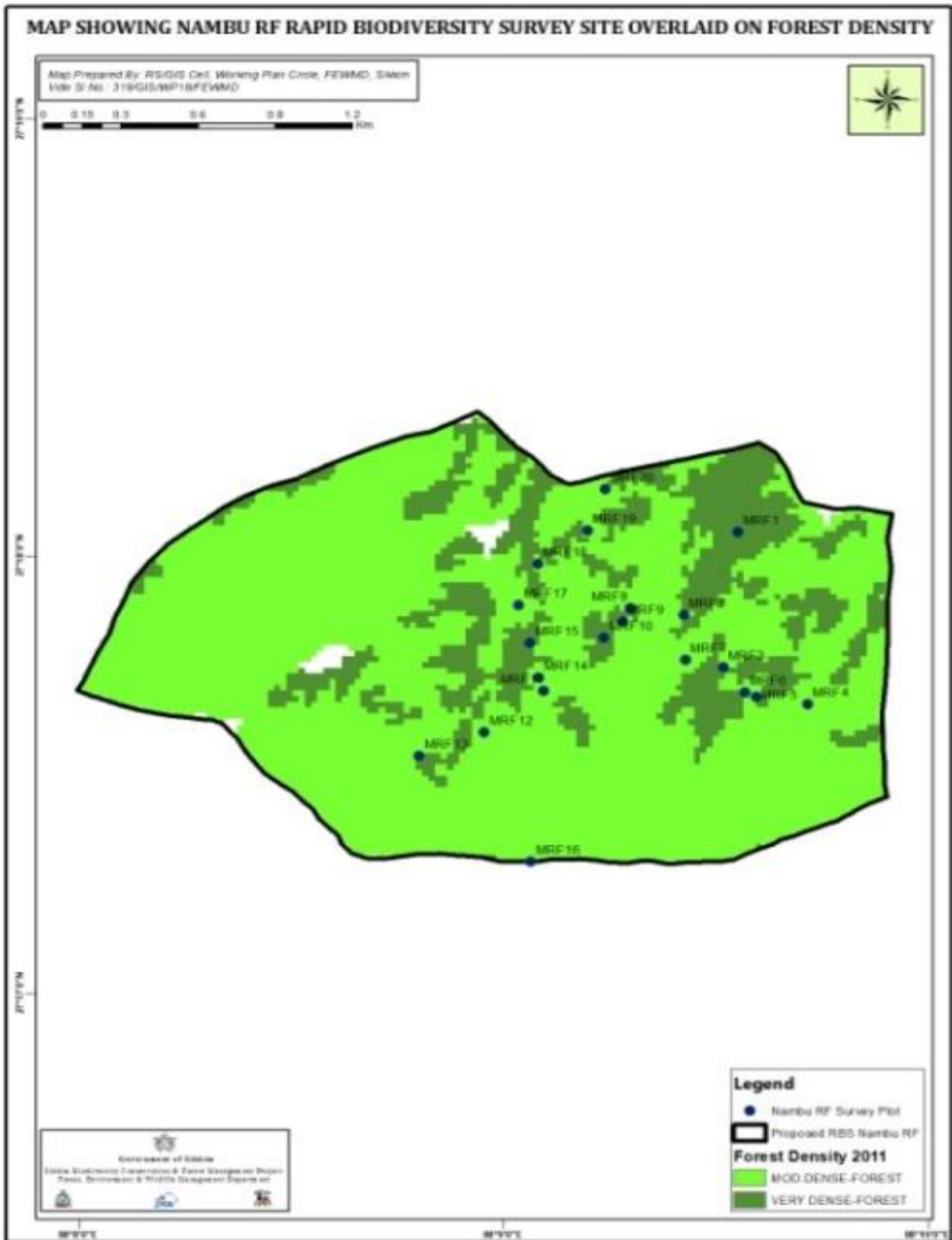


Figure 34: Rapid biodiversity survey plots along the sampling path of Nambu RF

| Table 28: Site Characteristics of the sampling plots of Nambu Reserve Forest, West Sikkim | | | | | | | | | |
|---|----------------------|------------------|-------------|-------------|-----------------|--------------|------------------|-------------------|---------|
| Site Code | Forest types | Altitude (m) asl | Coordinates | | Slope angle (°) | Slope aspect | Humus depth (cm) | Disturbance | |
| | | | Latitude | Longitude | | | | Anthropogenic | Natural |
| NRF1 | Wet Temperate forest | 1964 | 27°18'07.9" | 88°09'32.0" | 30 | E | 2 | | Natural |
| NRF2 | Wet Temperate forest | 2065 | 27°17'56.7" | 88°09'24.2" | 30 | SE | 1 | | Natural |
| NRF3 | Wet Temperate forest | 2166 | 27°17'49.4" | 88°09'29.7" | 30 | NE | 2 | | Natural |
| NRF4 | Wet Temperate forest | 2160 | 27°17'44.2" | 88°09'41.6" | 50 | E | 1 | | Natural |
| NRF5 | Wet Temperate forest | 2182 | 27°17'45.3" | 88°09'34.3" | 60 | NE | 1 | | Natural |
| NRF6 | Wet Temperate forest | 2190 | 27°17'45.9" | 88°09'32.7" | 50 | N | 1 | | Natural |
| NRF7 | Wet Temperate forest | 2157 | 27°17'50.5" | 88°09'24.4" | 60 | NE | 0.5 | | Natural |
| NRF8 | Wet Temperate forest | 2150 | 27°17'57.6" | 88°09'16.6" | 60 | SW | 2 | | Natural |
| NRF9 | Wet Temperate forest | 2169 | 27°17'55.8" | 88°09'15.6" | 30 | NE | 0.5 | Fodder collection | |
| NRF10 | Wet Temperate forest | 2163 | 27°17'53.6" | 88°09'12.9" | 60 | NE | 1 | | Natural |
| NRF11 | Wet Temperate forest | 2165 | 27°17'46.4" | 88°09'04.3" | 60 | N | 1 | | Natural |
| NRF12 | Wet Temperate forest | 2191 | 27°17'40.8" | 88°09'55.8" | 60 | S | 1 | | Natural |
| NRF13 | Wet Temperate forest | 2170 | 27°17'37.6" | 88°09'46.6" | 50 | W | 1 | | Natural |
| NRF14 | Wet Temperate forest | 2153 | 27°17'48.2" | 88°09'03.6" | 60 | SE | 2 | | Natural |
| NRF15 | Wet Temperate forest | 2128 | 27°17'53.0" | 88°09'02.4" | 60 | NE | 1 | | Natural |
| NRF16 | Wet Temperate forest | 2097 | 27°17'16.0" | 88°09'01.5" | 60 | NE | 3 | | Natural |
| NRF17 | Wet Temperate forest | 2039 | 27°17'58.2" | 88°09'00.9" | 40 | E | 1 | | Natural |
| NRF18 | Wet Temperate forest | 1999 | 27°18'03.8" | 88°09'03.7" | 60 | SW | 2 | | Natural |
| NRF19 | Wet Temperate forest | 1988 | 27°18'08.3" | 88°09'10.7" | 60 | N | 2 | | Natural |
| NRF20 | Sub-tropical Forest | 1980 | 27°18'14.0" | 88°09'13.3" | 50 | SW | 2 | | Natural |

METHODOLOGY

During 2017, random sampling plot of 10m x 10m was laid, depending upon the site feasibility, covering a total area of 0.20 ha. Within the main plot, all the standing tree species were enumerated and measured (CBH) at 1.37 m from the ground. Circumference at breast height (1.37 m) was taken for the determination of tree basal area. Basal area (m² / ha) was used to determine the relative dominance of a tree species. Within the subplots, 5m x 5m were laid for recording the sapling (no. of species & its height) and shrub for the percent cover was recorded. Quadrats of 1m x 1m were laid (5 corner) for seedling species; the same plot was used for recording the herb percentage in the area. Plant species were identified through herbarium record and flora (Hooker JD 1888-1890; Hooker JD 1849; Pradhan & Lachungpa 1990; Kholia 2010). The unidentified plants species in the field were photographed, and later identified by consulting plant taxonomist at G.B. Pant Institute (Sikkim Unit), Botanical Survey of India (BSI) and web references (www.efloras.org; www.flowersofindia.net, www.floraofchina) and by referring local people from the nearby villages. All the sampling plots were geotagged for reference under long-term monitoring and altitude was recorded.

Data Analysis

Data were analysed for density, frequency, abundance, relative density, relative frequency, relative dominance, Importance Value Index, etc. Species diversity (H), Species richness (I) and Species evenness (E) were calculated using standard formulas.

FINDINGS AND DISCUSSION

Vegetation Structure

A total of 128 species were recorded of which 52 herb species followed by tree 44 species, 10 shrubs/scrub, 13 climbers and 9 ferns and fern-allies. The area harbors over 15 orchid species were recorded (**Table 29**).

Table 29: Distribution of floral species recorded in Nambu Reserve Forest in West Sikkim

| Habit | Species | Genera | Family |
|--------------------|------------|------------|-----------|
| Tree | 44 | 37 | 25 |
| Shrub/Scrub | 10 | 9 | 8 |
| Herb | 52 | 41 | 23 |
| Fern & fern-allies | 9 | 9 | 8 |
| Climber/Epiphyte | 13 | 11 | 11 |
| Total | 128 | 107 | 75 |

Plant Life-form Spectrum

Life-form analysis provides an unambiguous picture of the biological spectrum represented in the current study area. The phanerophytes life forms exhibited by trees and shrubs and the herbs belongs to four major life forms viz., Chamaephytes (Ch), Hemicryptophytes (H), Cryptophytes (Cr) and Therophytes (Th). The hemicryptophytes (53.00%) is the highest lifeform followed by phanerophytes (39.00%) representing the canopy forming species (**Figure 35**). It is a well known fact that in the mixed temperate forest which has moderate canopy cover and the rich diversity of ground vegetation is secured. Herb layer plants perform a significant function in the majority of plant biodiversity by Von Oheimb & Hardtle (2009).

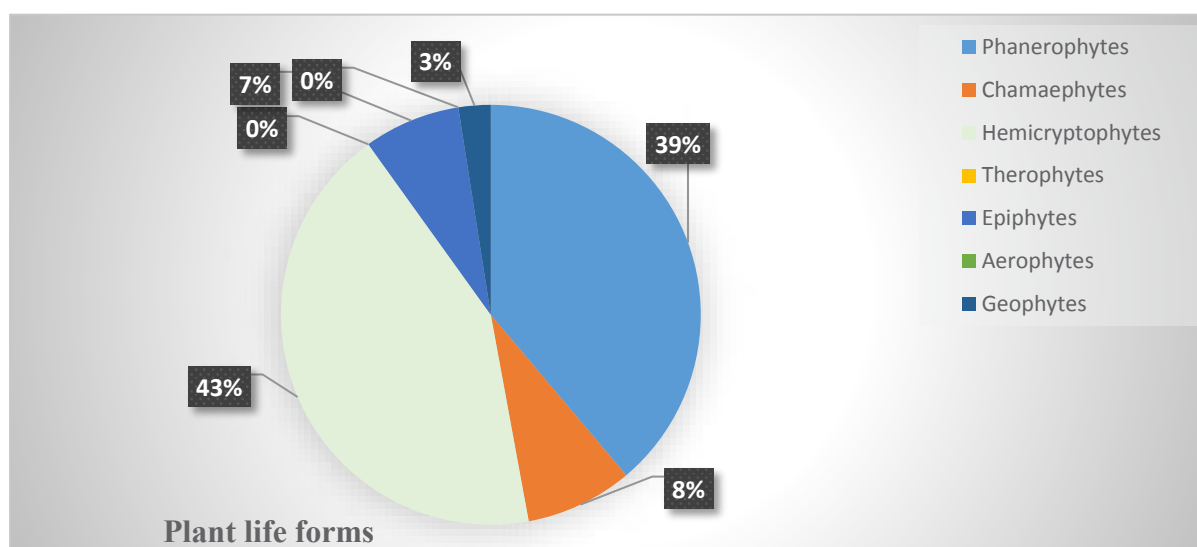


Figure 35: Plant life-form spectrum of plant species of Nambu Reserve Forest, West Sikkim

The therophytes and aerophytes were absent which is 0% in above figure. The absence of therophytes and aerophytes shows that the community is under some kind of environmental stress. The therophytes which thrive on harsh climatic condition and prosper largely in the hottest and driest region but Chaudhry *et al.* (2006) were absent in the site due to obvious absence of these extreme situation.

Species Diversity, Richness and Evenness

Shannon’s Index, McIntosh’s Index and Evenness showed significant results in different abundance, degree of evenness, and richness and diversity of tree species (**Table 30**).

In the present study, the tree has the highest species diversity index (H), the value is 3.22 followed by sapling (2.52) and seedling (2.51). The species diversity index value generally between 1.5 and 3.5 in most ecological studies and the index is rarely greater than 4 in temperate forest. Species diversity is one of the most important indices used for evaluating the sustainability of forest communities (Rad *et al.*, 2009). The Shannon Index increases both the wealth and the uniformity of the community. Regarding the highest species richness, trees recorded the highest value (35.82) followed by sapling (20.82) and seedling (18.82) as compared to the species evenness of tree (0.90) followed by seedling (0.85) and sapling (0.83; **Table 30**).

| | Species diversity (H) | Species richness (I) | Species evenness (E) |
|----------|-----------------------|----------------------|----------------------|
| Tree | 3.22 | 35.82 | 0.90 |
| Sapling | 2.52 | 20.82 | 0.83 |
| Seedling | 2.51 | 18.82 | 0.85 |

Many researchers has found out that the species richness decreases due to many environmental factors in higher elevation. Pausas & Austin (2001) suggested that the distribution of species richness is likely to be governed by two or more environmental factors and not by single factor. Sometimes high altitudes do not substantially weaken the effects of

monsoons, nor are they significantly different from those of high rainfall Himalayas. This has been used to explain the patterns of decrease in species richness with altitude.

The present study, the tree species richness was maximum in the wet temperate forest. The overall pattern of species richness showed a sharp decline as the altitude increased beyond 3000 m asl.

Plant Density, Frequency and Abundance

The tree species were recorded cumulatively, viz., adult, sapling and seedling in all the sampling plot. The highest adult individuals were recorded for *Symplocos lucida* (160.00 Ind/ha) followed by *Quercus lamellosa* (155.00 Ind/ha), *Castanopsis hystrix* (150.00 Ind/ha), and *Symplocos glomerata* (130.00Ind/ha). Whereas, in sapling category, the highest individual plant density was recorded for *Quercus lamellosa* (960.00 Ind/ha) followed by *Symplocos lucida* (840.00 Ind/ha). In seedling category, the highest individual plant density was recorded for *Beilschmiedia sikkimensis* (26500 Indi/ha) and *Actinodaphne sikkimensis* (23000Ind/ha) (**Table 31**). Regarding relative frequency, the maximum number of occurrences was recorded for *Quercus lamellosa* (9.68) followed by *Castanopsis hystrix* (8.06).

| Table 31: Individual plant species per hectare of major species (Individual Plant density/ha) | | | |
|--|-------------|----------------|-----------------|
| Species Name and Family | Tree | Sapling | Seedling |
| <i>Acer campbellii</i> Hook. & Thom. Ex Hiern. [Sapindaceae] | 60 | 200 | 12000 |
| <i>Actinodaphne sikkimensis</i> Meisn. [Lauraceae] | 25 | 60 | 25500 |
| <i>Alangium begoniaefolium</i> [Alangiaceae] | 45 | 80 | |
| <i>Alnus nepalensis</i> Don. [Betulaceae] | 15 | 100 | |
| <i>Beilschmiedia sikkimensis</i> King ex Hook. f. [Lauraceae] | 20 | 60 | 29000 |
| <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. [Fagaceae] | 150 | 580 | 15000 |
| <i>Castanopsis indica</i> . [Fagaceae] | 50 | 100 | |
| <i>Castanopsis tribuloides</i> (Smith) A. DC. [Fagaceae] | 35 | | |
| <i>Choerospondias axillaris</i> (Roxb.) B.L.Burt & A.W.Hill. [Anacardiaceae] | 20 | | |
| <i>Cryptomeria japonica</i> (Thunberg ex. Linn. F.) D. Don. [Taxodiaceae] | 15 | | |
| <i>Echinocarpus dasycarpus</i> [Elaeocarpaceae] | 20 | | |
| <i>Elaeocarpus lanceifolius</i> Roxb. [Elaeocarpaceae] | 35 | 100 | 2000 |
| <i>Engelhardtia spicata</i> Lechen ex Blume. [Juglandaceae] | 15 | 140 | 4500 |
| <i>Eurya acuminata</i> [Theaceae] | 30 | 200 | 3500 |
| <i>Exbucklandia populnea</i> (R. Br. Ex Griff) R. W. Br. | 20 | | |

| | | | |
|---|-----|-----|-------|
| [Hamamelidaceae] | | | |
| <i>Ficus nemoralis</i> [Moraceae] | 35 | | |
| <i>Glochidion acuminatum</i> Muell. [Euphorbiaceae] | | | 2500 |
| <i>Juglans regia</i> L.[Juglandaceae] | 25 | | |
| <i>Lithocarpus pachyphyllus</i> (Kurz) Rehder. [Fagaceae] | 25 | 60 | |
| <i>Lyonia ovalifolia</i> var. <i>ovalifolia</i> . [Ericaceae] | 25 | | 2500 |
| <i>Macaranga denticulata</i> (Blume) Müll.Arg.[Euphorbiaceae] | 15 | | |
| <i>Machilus edulis</i> [Lauraceae] | 15 | 60 | 3000 |
| <i>Machilus</i> sp. [Lauraceae] | 15 | | |
| <i>Maesa</i> sp. [Myrtaceae] | 20 | | 4500 |
| <i>Magnolia doltsopa</i> [Magnoliaceae] | 40 | 120 | 6000 |
| <i>Meliosma arnottiana</i> (Wight) Walp. [Sabiaceae] | 20 | | 2500 |
| <i>Nyssa javanica</i> [Cornaceae] | 20 | | |
| <i>Persea odoratissima</i> (Nees) Kosterm. [Lauraceae] | 45 | 80 | |
| <i>Pyralia edulis</i> (Wall.) A. DC. [Santalaceae] | 15 | 60 | 1500 |
| <i>Quercus lamellosa</i> Sm. [Fagaceae] | 155 | 960 | 18000 |
| <i>Rhus chinensis</i> Mill. [Anacardiaceae] | 25 | | |
| <i>Rhus succedanea</i> Linn. [Anacardiaceae] | 15 | | |
| <i>Rhododendron arboreum</i> [Ericaceae] | | 60 | |
| <i>Symplocos lucida</i> [Symplocaceae] | 160 | 840 | |
| <i>Symplocos glomerata</i> King ex C.B. Clarke. [Symplocaceae] | 130 | 500 | |
| <i>Tetradium fraxinifolium</i> (Hook. f.) T.G. Hartley [Rutaceae] | 35 | 140 | |

Distibution Patterns (A/F) Ratio

Table 32: List of random distribution pattern of major tree species

| Species | Tree | Seedling |
|---|------|----------|
| <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. | - | 0.05 |
| <i>Quercus lamellosa</i> Sm. | 0.04 | 0.05 |
| <i>Symplocos lucida</i> D. Don | 0.05 | - |

According to Odum (1971), contiguous distribution is the commonest pattern in nature, random distribution is found only in very uniform environment and the regular distribution occurs where severe competition between the individual exists. Under the regular (<0.025), random (0.025 to 0.05) and contiguous (>0.05) distribution, the values indicate that all the adult individuals tree species exhibits contiguous distribution. In the present study, amongst the major tree species, *Quercus lamellosa* and *Symplocos lucida* were found to be

random distribution pattern. There is no random distribution in sapling category whereas in seedling category, *Castanopsis hystrix* and *Quercus lamellosa* were found the random distribution patterns. The other remaining plants species were recorded as contiguous distribution pattern as shown in **Table 32**.

Shrub Category

A total of 13 species of shrubs belonging to 13 genera and 9 family was recorded all along the sampling plots. The family-wise species composition the highest two taxa was recorded from Adoxaceae, Berberidaceae, Melastomataceae and Thymeaceae. The other remaining families were represented by single species (**Figures 35 & 36**).

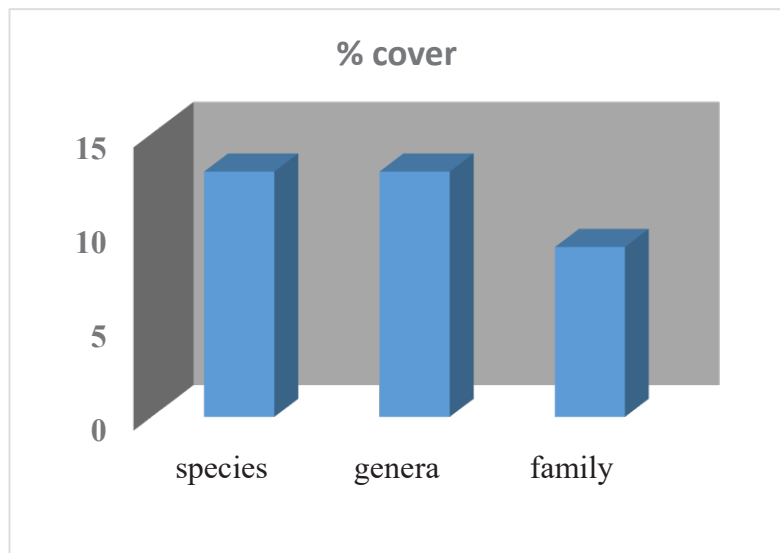


Figure 35: Percent cover of shrub and scrub species

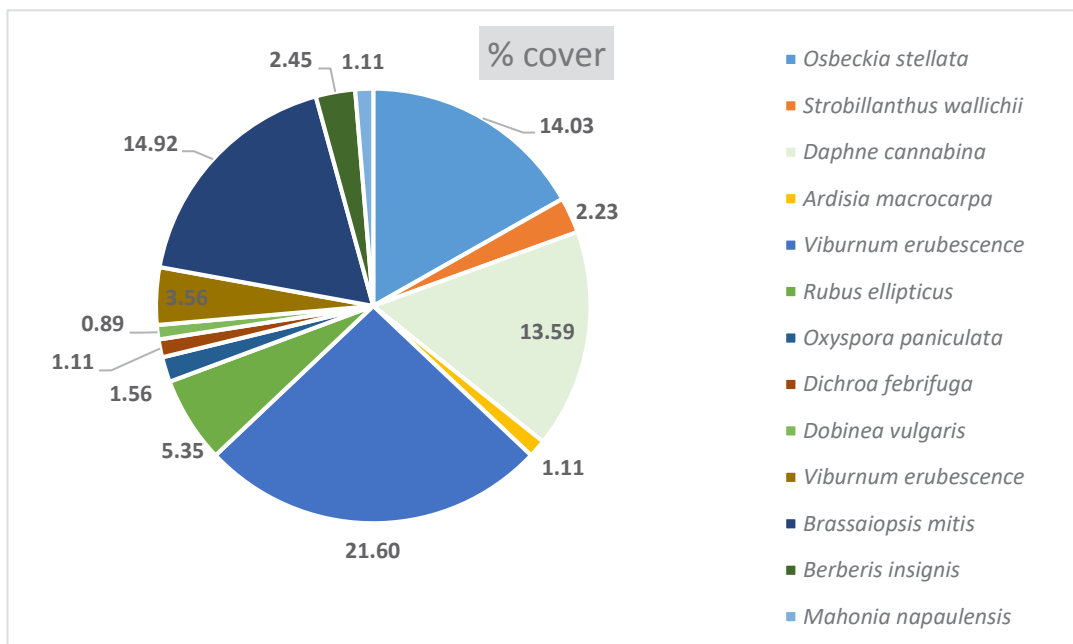


Figure 36: Percent cover of shrub and scrub species

Herb

The phytosociological analysis indicates that the herbaceous species were randomly distributed with maximum percent cover. A total of 59 species were recorded from 20 sampling plots, of which, *Swertia bimaculata* had the highest percent cover (44.32%) followed by *Elastostema platyphyllum* (22.27%), *Digitaria* sp. (15.59%), *Polygonum molle* (14.03%), *Cyperus eragrostis* (10.24%), *Begonia* sp., (6%), *Polygonatum* sp., (6.6%), *Pilea umbrosa* (5.5%), *Rubus calycinus* (4.4%), *Eupatorium adenophorum* (4.9%), *Centella asiatica* (4.4%), *Bidens pilosa* (4.0%), *Astilbe rivularis* (4.0%), *Artemisia vulgaris* (3.11%), *Rubus niveus* (3.1%), *Rumex nepalensis* (2.4 %), *Selinum* sp., (2.6%), *Nepeta* sp., (2.4%), *Impatiens* sp., (2.2%), *Gaultheria* sp., (2.8%), respectively. The herb layers composition in temperate forest is largely determined by soil fertility, light and water availability. Furthermore, tree species have different shading characteristics and thus affect light flux to the forest floor (**Figure 37**).

FAUNAL DIVERSITY

During the survey, 4 species of fauna were recorded along the sampling plots. Further, a total of 21 bird species belonging to 14 families were recorded. The family-wise bird species composition for Turdidae and Corvidae (3 species each) followed by Dicaeidae, Paridae, Phasinidae (2 species each) from this particular transect. The other remaining family represented by single species (**Table 33**).

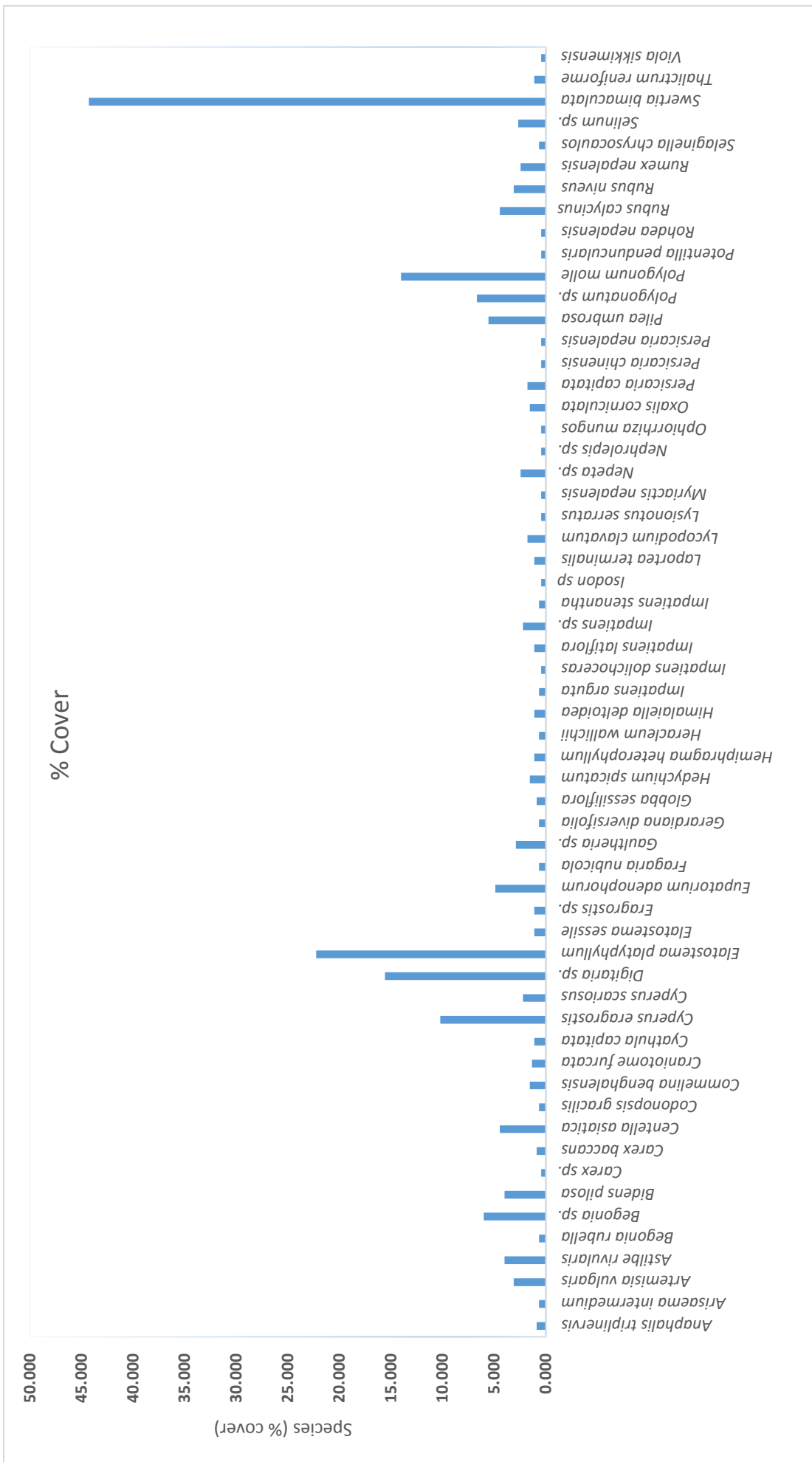


Figure 37: Percent cover of herbs species found in Nambu Reserve Forest, West Sikkim

Table 33: Checklist of fauna and avifauna species encountered at Nambu Reserve Forest, West Sikkim

| Sl. No | Scientific Name | Family | Common Name | Local Name |
|--------------------------|---------------------------------|---------------|------------------------------|-------------|
| Fauna Species | | | | |
| 1 | <i>Muntiacus muntjak</i> | Cervidae | Barking deer | Mirga |
| 2 | <i>Ursus thibetanus</i> | Carnivora | Himalayan black bear | Bhalu |
| 3 | <i>Cuon alpinus</i> | Carnivora | Wild dog | Ban kukur |
| 4 | <i>Canis sp.</i> | Carnivora | Common jackal | Syall |
| Avi-fauna Species | | | | |
| 1 | <i>Aegithalos iouschistos</i> | Paridae | Rufous-fronted tit | Fista |
| 2 | <i>Cettia major</i> | Sylviidar | Chestnut-crowned warbler | Fista |
| 3 | <i>Fulvetta vinipectus</i> | Paridae | Coal tit | Fista |
| 4 | <i>Corvus macrorhyncus</i> | Corvidae | Jungle crow | Khag |
| 5 | <i>Cuculus canorus</i> | Cuculidae | Eurassian | Cuckoo |
| 6 | <i>Dendrocopos darjellensis</i> | Picidae | Darjeeling woodpecker | Laachey |
| 7 | <i>Dicrurus leucophaeus</i> | Dicaeidae | Ashy drongo | Chibey |
| 8 | <i>Dicrurus macrocercus</i> | Dicaeidae | Black drongo | Chibey |
| 9 | <i>Garrulax leucolophus</i> | Turdidae | White-crested laughingthrush | Kolkoley |
| 10 | <i>Garrulax ocellatus</i> | Turdidae | Spotted laughingthrush | Kolkoley |
| 11 | <i>Gypaetus barbatus</i> | Accipitridae | Lammergeier | Chill |
| 12 | <i>Lophura leucomelanos</i> | Phasinidae | Kalij pheasant | Kalij |
| 13 | <i>Megalaima virens</i> | Megalaimidae | Great barbet | Neual |
| 14 | <i>Myophonus caeruleus</i> | Turdidae | Blue whistlingthrush | Kalchura |
| 15 | <i>Passer rutilans</i> | Passeridae | Russet sparrow | Bhangera |
| 16 | <i>Pycnonotus cafer</i> | Pycnonotidae | Red-vented bulbul | Jureli |
| 17 | <i>Streptopelia orientalis</i> | Columbidae | Oriental turtle dove | Dhukur |
| 18 | <i>Urocissa ornata</i> | Corvidae | Yellow-billed blue magpie | Lampucharey |
| 19 | <i>Corvus macrorhyncus</i> | Corvidae | Large-billed crow | Kag |
| 20 | <i>Arborophila torqueola</i> | Phasinidae | Hill partridge | Peura |
| 21 | <i>Aethopygia nicauda</i> | Nectariniidae | Fire-tailed sunbird | Balchi |
| Butterfly Species | | | | |
| 1. | <i>Argynnis childreni</i> | Nymphalidae | Large silverstripe | |
| 2. | <i>Aglais caschmirensis</i> | Nymphalidae | Indiantortoise shell | |
| 3. | <i>Cethosia cyane</i> | Nymphalidae | Lacewing | |
| 4. | <i>Eurema hecabe</i> | Pieridae | Grass yellow | |
| 5. | <i>Heliophorus brahma</i> | Lycaenidae | Golden sapphire | |
| 6. | <i>Chersonesia risa</i> | Nymphalidae | Common maplet | |

CONCLUSION

The present study concludes that the area has the highest lifeforms recorded for hemicryptophytes which represent that the ground vegetation was higher in site. It is well known that in temperate mixed forests, which have a moderate canopy, rich diversity of soil vegetation is ensured. Herb layer plants perform a significant function in the majority of plant biodiversity as mentioned by Von Oheimb & Hardtle (2009). The lack of thermophytes and aerophytes indicate that the community is under some kind of environmental stress. The therophytes which thrive on harsh climatic condition and prosper largely in the hottest and driest region were absent in the site due to obvious absence of these extreme situation (Chaudhry *et al.* 2006). The good species diversity index (H), the values of tree species is 3.22 followed by sapling (2.52) and seedling (2.51), the plant density was higher for *Symplocos lucida* and *Quercus lamellosa*, *Castanopsis hystrix* and *Symplocos glomerata*. The area is densely covered with small tree *Symplocos lucida*. The presence of *Symplocos lucida* indicates the presence of the Himalayan black bear in the forest. During the study period, the disturbance, the felling of trees and many other indirect evidences were registered. Therefore, it is concluded that the area is rich in flora and fauna.



Japalura variegata

Quantitative Analysis of Vegetation and Faunal Assessment of Temperate Region of Rayong Reserve Forest Sampling Path in South Sikkim, India

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Abstract

Rapid biodiversity survey was conducted in the sampling path of temperate region of Rayong Reserve Forest. Vegetation analysis was done using quadrat method by laying 44 sampling plots wherein a total of 109 floral species belonging to 92 genera and 58 families were recorded. The largest family was represented by Rosaceae (6.48%) followed by Fagaceae, Urticaceae and Orchidaceae (5.56%). Phanerophytes (51.05%), Hemicryptophytes (16.78%), Geophytes (13.29%) and Chamaephytes (8.39%) represented the life forms. *Cryptomeria japonica* (181.81 ± 1.77 ind/ha) showed highest density followed by *Symplocos lucida* (100.00 ± 0.25 ind/ha) and *Symplocos glomerata* (68.18 ± 0.33 ind/ha) while the lowest density (4.55 ± 0.00 ind/ha) was recorded for *Beilschmiedia sikkimensis*, *Betula alnoides*, *Brassiopsis hispida*, *Garuga pinnata*, *Prunus bracteopadus* and *Toxicodendron hookeri*. The highest density for sapling and seedling was recorded for *Symplocos lucida* (181.82 ± 0.78 ind/ha and 220.45 ± 1.75 ind/ha), respectively. The maximum frequency was recorded for *Symplocos lucida* (45.45%) and *Symplocos glomerata* (31.82%) while the lowest frequency of occurrence (4.55%) was observed for *Betula alnoides*, *Elaeocarpus lanceifolius*, *Juglans regia*, etc. The abundance to frequency ratio was observed for all the tree species showing contiguous distribution (97.30%) while only 1 species showed random distribution (2.70%) but none of the species showed regular distribution. The IVI values ranged between 1.093 and 117.170 with the highest value recorded for *Symplocos lucida* (117.170). The temperate zone was comparatively rich in terms of tree richness ($I = 36.83$) and tree species diversity ($H' = 2.98$). *Viburnum erubescens* had the widest availability in the area with highest percent cover of 36.6%. The frequency of occurrence value for herbs ranged between 2.3 and 59.1 while the percent cover ranged between 0.11 and 13.1.

Keywords: Rapid biodiversity survey; Vegetation analysis; Temperate forest; Rayong reserve forest

INTRODUCTION

The vegetation of each forest is a distinct floristic composition of plant communities that form a basis for an ecosystem of a region. These plant communities are formed by specific plant species and physiognomy having its own structural, functional and spatial features constituting the biodiversity of an area. Species composition, community structure and function are the most important ecological attributes of forest ecosystems in response to environmental as well as anthropogenic variables (Bisht & Bhat 2013; Dar & Sundarapandian 2016; Gairola *et al.* 2008; Shaheen *et al.* 2012). The temperate forests are globally important and unique as they provide critical ecosystem services and serve the world's major source of timber and wood products and are perhaps the only forests with some proven potential for sustainable management (de Gouvenain & Silander 2016). The species richness and diversity of a forest ecosystem are essential to the biodiversity as they provide resources and habitat for biodiversity and livelihood for humans, and provide watershed protection, prevent soil erosion and mitigate climate change. The temperate forests of Sikkim Himalaya is characterized into temperate broad-leaved forest (1700m – 2700m) dominated by oak, maple, birch and mixed coniferous temperate forest (2700m – 3000m) dominated by *Abies densa*, *Tsuga dumosa*, *Larix* sp., etc.

Biodiversity assessment of plant community composition, its distribution and abundance is helpful in understanding the forest structure which in turn is useful in planning and implementing conservation strategy of the community. In this regard, various field studies of vegetation have been carried out in different forest types of Sikkim for evaluation of biodiversity. This has become necessary as initiatives for preserving biodiversity in Sikkim has led to an increase of its forest cover by over 4% since 1993 from 43.95% to 47.62% in 2017 as per the latest India State of Forest Report 2017 (<http://www.sikkimforest.gov.in>). Vegetation field study first began in the early 19th century with the work of Alexander von Humbolt (1805) in plant geography (Randall 1978). Numerical methods of quantitative analysis have been developed mainly in relation to the vegetation of temperate regions (Greig-Smith *et al.* 1967). The quantitative study of vegetation is called Phytosociology as termed by Paczoski in 1896 (Gehu 2011).

Subba *et al.* (2015) have carried out the vegetation analysis in the temperate forest of Lachung range of Sikkim Himalaya where a total of 75 species under 68 genera in 49

families were recorded. *Picea spinulosa* showed highest density (214.81ind/ha), relative density (38.16%) and IVI (75.76) followed by *Tsuga dumosa* (81.48ind/ha). Highest relative frequency of occurrence was recorded for *Picea spinulosa* and *Tsuga dumosa* (21.40% each) followed by *Rhododendron arboreum* (11.52%). For saplings and seedlings, the highest score was observed in *Rhododendron arboreum* (37.0% and 22.2%) followed by *Prunus nepalensis* (33.3% and 22.2%); lowest sapling was recorded for *Populus jacquemontiana* (3.7%) and seedling for *Sorbus* sp. and *Magnolia globose* (3.7% each). The species diversity (adult, sapling and seedlings) in the site were found to be highest in concentration for the trees ($H' = 2.2914$) followed by seedlings ($H' = 2.2124$) and the saplings ($H' = 2.1474$). The highest IVI value recorded for *Tsuga dumosa* effectively makes it the dominant species. Abundance-to-frequency ratio revealed that random distribution was evinced in *Tsuga dumosa* and the rest showed contiguous distribution.

Subba *et al.* (2017) recorded 88 floral species of which 33 trees species, 30 herbs, 12 shrubs/scrubs, 10 climbers and 1 epiphyte along the sampling path of temperate forest at Sang – Tinjure area of FambongLho Wildlife Sanctuary in Sikkim. The highest adult individual was recorded from *Castanopsis tribuloides* (387.50ind/ha) followed by *Leucosceptum canum* (212.50ind/ha). Importance Value Index of adult tree was recorded highest for *Castanopsis tribuloides* (62.7) followed by *Quercus lamellosa* (22.6), *Symplocos lucida* (20.9) and *Symplocos glomerata* (13.2). The abundance-to-frequency ratio revealed all the adult individuals of tree to be contagiously distributed except for *Acer caudatum* and *Cinnamomum impressinervium* which showed random distribution while none of the species showed regular distribution. The species diversity (H') and richness of trees (adult, sapling and seedlings) in the site were found highest in concentration for the tree ($H' = 3.17$) followed by seedling ($H' = 2.68$) and sapling ($H' = 2.60$) in the area of 0.064ha. Likewise, many related work has been conducted by Bharat *et al.* (2015a & b), Dahal *et al.* (2017), Pradhan & Lachungpa (1990), Rai & Rai (1993), Subba *et al.* (2016), Subba *et al.* (2018), Sundriyal & Sharma (1996) and Singh & Chauhan (1997).

The present study focused on the analysis of biodiversity assessment based on the species recorded in the temperate forest of Rayong Reserve Forest in South Sikkim.

STUDY AREA

Rayong Reserve Forest is located in the district of South Sikkim that lies between 27°14'28.69"N – 27°19'33.9"N latitude and 88°19'56.18"E – 88°22'32.10"E longitude. It covers a total area of 13.58 sq.km and the altitude of the forest ranges from 1700m to 2390m asl. The reserve forest lays in 7 compartments namely Rayong 1, Rayong 2, Rayong 3, Rayong 4, Rayong 5, Rayong 6 and Rayong 7 that falls under the jurisdiction of Rabong Block in Rabong Range. A part of the forest encloses Rayong busy standing at an elevation of 2147m asl lying within compartment 2 and Rabong lying within compartment 6.

The survey was conducted in the temperate forest along the altitudinal range from 1758m asl to 2374m asl lying between 27°14'34.58"N – 27°17'0.3"N latitude and 88°19'56.38"E – 88°22'12.62"E longitude covering a distance of 0.44ha approximate. A total of 44 plots were laid covering 3 compartments, i.e., Rayong 1, 2 & 3 which is represented in the map below (**Figure 38**).

The vegetation of the surveyed path is a mild variation of sub-tropical and wet-temperate type. However, as per our survey, we came across the temperate forest type where the density of the forest was moderately dense. Since the altitude of the forest ranges from 1758m to 2374m asl, the forest was largely a wet temperate covering all the compartments with only a part of it being sub-tropical.

The starting point of the survey was from Rayong busy (2147m) where the surrounding forest was largely dominated by *Cryptomeria japonica* covering large areas and forming dense forests. The ground vegetation underneath these forests was scanty due to lack of sunlight and unstable substratum. Only a few ferns were seen growing on the fringes of such forests. However, *Rohdea nepalensis*, a medicinal value for diabetes and an appetizer, was found to be growing under *Cryptomeria* vegetation near Rayong busy.

The forest covers a large number of oak trees dominating the forest constituting the greater part of the trees canopy. Some commonly occurring oak species in this forest are *Castanopsis hystrix* mostly found between 1816m and 1970m, *Castanopsis tribuloides* (1950m–2299m), *Lithocarpus elegans* (1800m–2300m), *Lithocarpus pachyphyllus* (1800m–2303m) and *Quercus lamellosa* (1700m–2280m). According to the Forest Survey of India,

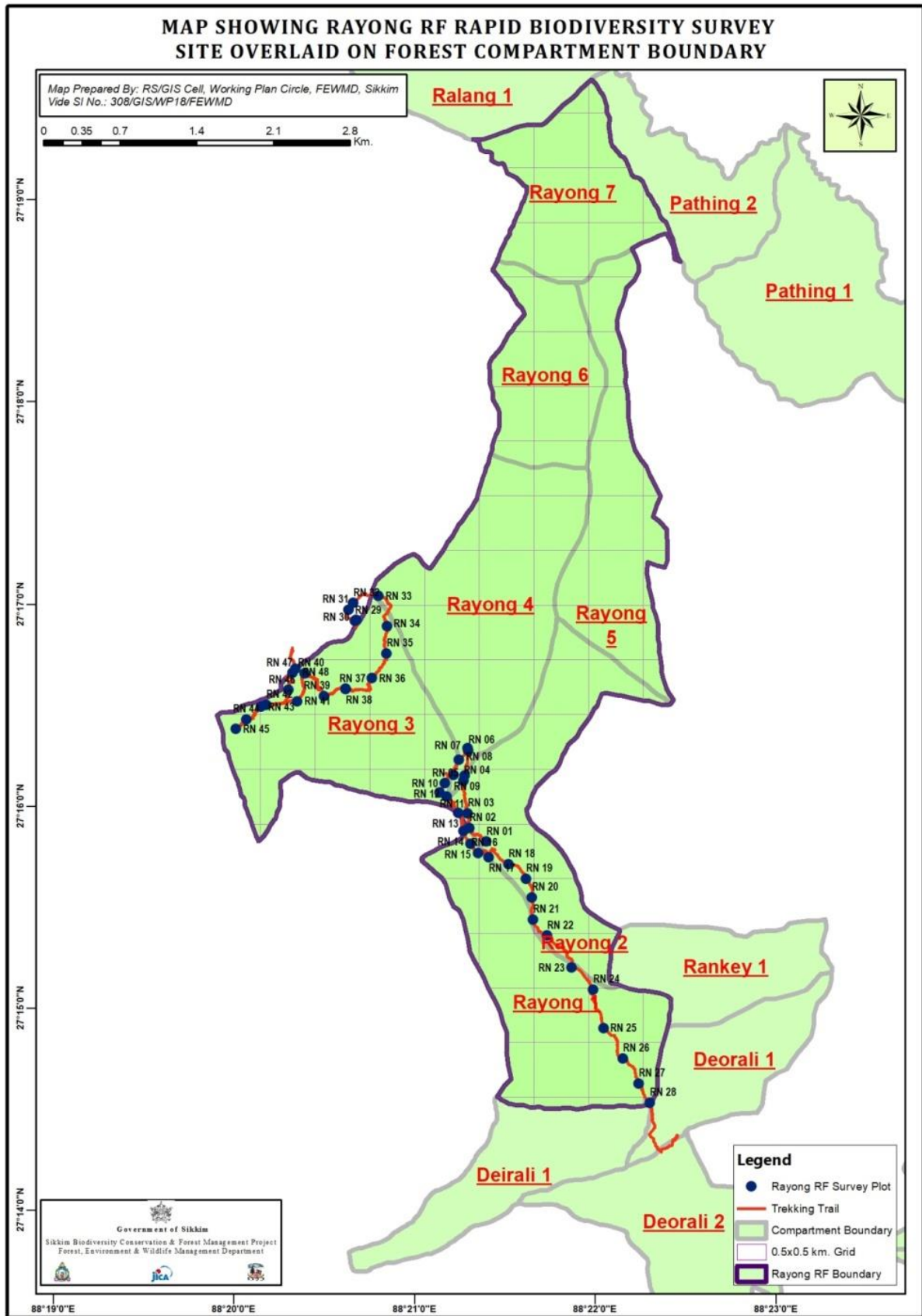


Figure 38: Rapid biodiversity survey sites along the sampling path of Rayong RF

trees of CBH 20 – 26feet are demarcated as heritage trees and such trees of oak were recorded in the forest during the survey. *Castanopsis hystrix* with CBH 20ft (609.6cm) and *Quercus lamellosa* with CBH 26ft (792.48cm) were recorded at elevations of 1947m asl and 2231m asl, respectively. *Acer campbellii*, *Magnolia doltsopa*, *Engelhardtia spicata*, *Exbucklandia populnea*, *Symplocos glomerata*, *Symplocos lucida* and *Eurya acuminata* are quite common in the forest upto 2300m. Saplings and seedlings of *Lithocarpus* and *Symplocos* are widely dispersed indicating good regeneration of the species in the forest. Other common trees available in this zone are *Quercus lamellosa*, *Beilschmiedia sikkimensis*, *Betula alnoides*, *Elaeocarpus lanceifolius*, *Garuga pinnata*, *Juglans regia*, *Lyonia ovalifolia*, *Pyrularia edulis* and *Zanthoxylum acanthopodium*.

The commonly found shrubs in the forest are *Rubus ellipticus*, *R. parviflorus*, *R. paniculatus*, *Osbeckia stellata*, *Daphne papyracea*, *Viburnum erubescens* and *Mahonia napaulensis*. The oaks have branched crowns and are abundantly covered with mosses and other epiphytes such as *Agapetes serpens*, *Tetrastigma* species and *Raphidophora decursiva*. Epiphytic orchids such as *Pleione praecox*, *Dendrobium longicornu*, *Coelogyne fuscescens* and *Otochilus fuscus* are the common orchids found covering the trees especially the oaks and *Cryptomeria japonica*.

Trees are also seen covered with climbers such as *Cissus elongata*, *Piper boehmeriifolium*, *Clematis buchananiana*, *Herpetospermum pedunculatum*, *Trichosanthes lepiniana*, *Rubia manjith* and *Dactylicapnos scandens*. The ground vegetation is mostly a habitat for herbs like *Anaphalis triplinervis*, *A. margaritacea*, *Carex* species, *Elatostema platyphyllum*, *Hedychium spicatum*, *Impatiens racemosa*, *Persicaria runcinata*, *P. capitata*, *Polygonum molle*, *Rubus calycinus*, *Urtica parviflora* and *U. dioica*. Other commonly occurring ground vegetation were ferns such as *Selaginella* species, *Lycopodium japonicum*, *Diplazium dilatatum* and *Gleichenia longissima*. A large patch of ground is covered with *Cotoneaster* and *Gaultheria* species.

Further into the forest, bamboo species of *Yushania maling* (Malingo), *Himalayacalamus hookerianus* (Pareng) and *Himalayacalamus falconeri* (Singanay baas) are found in dense and mild population. Their presence forms an important aspect as a soil binding property. While *Yushania maling* (Malingo) bamboo is densely populated along 2202m – 2374m asl, *Himalayacalamus hookerianus* (Pareng) and *H. falconeri* (Singanay baas) are seen occurring in the forest occasionally. Numerous medicinal plants as herbal

remedies for treatment of various ailments such as *Swertia chirayita*, *S. bimaculata*, *Astilbe rivularis*, *Centella asiatica*, *Rohdea nepalensis*, *Ageratina adenophora*, *Oxalis corniculata*, *Dichroa febrifuga* and *Solanum aculeatissimum* are also found to be growing in the forest.

SAMPLING DESIGN AND DATA COLLECTION

The study was carried out in 2017 using standard quadrat method the site characteristics of which are given in **Table 34**. Plots of 10m x 10m quadrat for trees were laid. Within the plots, girths of trees (>30cms) were measured at 1.3m above the ground. Depending on girth size, the recorded individuals were divided into 10 girth classes of 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, >100cm. Within the mother plot, 5 sub-plots for shrubs and saplings were laid through 5m x 5m quadrat (4 in the corner and 1 at the centre). Herbs and seedlings were sampled by laying 1m x 1m quadrat. The plots were laid at places of variable vegetation growth. With the help of GPS, latitude and longitude along with elevations were also calibrated in the entire sampling plots. General listing and photography outside the plots were also done.

Data were quantitatively analyzed for density, frequency, abundance, importance value index (IVI), species diversity (Shannon-Weiner index H'), species richness (I) and species evenness (E) using standard formulae.

Table 34: Site characteristics of the sampling plots along the temperate forest of Rayong Reserve Forest

| Site code | Forest Type | Altitude (m) | GPS coordinates | | Slope Aspect | Slope Angle (°) | Canopy Cover (%) |
|-----------|------------------------|--------------|-----------------|---------------|--------------|-----------------|------------------|
| | | | Latitude (N) | Longitude (E) | | | |
| RRF 01 | Moderate Wet temperate | 1758 | 27°15'46.94 | 88°21'19.22 | S | 15 | 35 |
| RRF 02 | Moderate Wet temperate | 2220 | 27°15'51.05 | 88°21'13.68 | S | 20 | 15 |
| RRF 03 | Moderate Wet temperate | 2202 | 27°15'55.37 | 88°21'13.14 | SE | 15 | 20 |
| RRF 04 | Moderate Wet temperate | 2276 | 27°16'5.16 | 88°21'11.84 | NW | 15 | 40 |
| RRF 05 | Moderate Wet temperate | 2299 | 27°16'6.67 | 88°21'12.35 | SE | 45 | 30 |
| RRF 06 | Dense Wet temperate | 2303 | 27°16'14.16 | 88°21'13.61 | SE | 45 | 50 |
| RRF 07 | Moderate Wet temperate | 2308 | 27°16'14.79 | 88°21'13.39 | NW | Mild | 40 |
| RRF 08 | Moderate Wet temperate | 2328 | 27°16'11.42 | 88°21'10.50 | NE | Mild | 15 |
| RRF 09 | Moderate Wet temperate | 2319 | 27°16'06.81 | 88°21'08.56 | W | 15 | 20 |
| RRF 10 | Moderate Wet temperate | 2361 | 27°16'04.48 | 88°21'05.62 | N | 10 | 40 |
| RRF 11 | Moderate Wet temperate | 2374 | 27°16'01.63 | 88°21'03.94 | N | 20 | 30 |
| RRF 12 | Moderate Wet temperate | 2350 | 27°16'00.40 | 88°21'06.13 | N | 35 | 40 |
| RRF 13 | Moderate Wet temperate | 2272 | 27°15'55.57 | 88°21'10.00 | NW | 35 | 45 |
| RRF 14 | Moderate Wet temperate | 2225 | 27°15'50.15 | 88°21'11.68 | NE | 15 | 35 |
| RRF 15 | Moderate Wet temperate | 2213 | 27°15'46.33 | 88°21'14.07 | W | Mild | 30 |
| RRF 16 | Dense Wet temperate | 2213 | 27°15'43.53 | 88°21'16.38 | SW | Mild | 60 |
| RRF 17 | Dense Wet temperate | 2192 | 27°15'42.27 | 88°21'19.88 | NE | 15 | 65 |
| RRF 18 | Moderate Wet temperate | 2170 | 27°15'40.17 | 88°21'26.59 | W | 55 | 40 |
| RRF 19 | Dense Wet temperate | 2173 | 27°15'35.77 | 88°21'32.23 | NE | 35 | 60 |
| RRF 20 | Moderate Wet temperate | 2167 | 27°15'30.27 | 88°21'34.25 | NW | 30 | 15 |
| RRF 21 | Moderate Wet temperate | 2191 | 27°15'23.65 | 88°21'34.50 | NW | Mild | 10 |
| | Moderate Wet | | | | | | |

| | | | | | | | |
|---|------------------------|------|-------------|-------------|----|------|----|
| RRF 23 | Dense Wet temperate | 2231 | 27°15'09.31 | 88°21'47.05 | E | 30 | 60 |
| RRF 24 | Dense Wet temperate | 2262 | 27°15'02.58 | 88°21'54.14 | W | Mild | 55 |
| RRF 25 | Dense Wet temperate | 2279 | 27°14'51.19 | 88°21'57.45 | NW | Mild | 75 |
| RRF 26 | Moderate Wet temperate | 2333 | 27°14'42.11 | 88°22'03.82 | NW | 35 | 40 |
| RRF 27 | Dense Wet temperate | 2311 | 27°14'34.58 | 88°22'08.98 | N | 60 | 55 |
| RRF 28 | Moderate Wet temperate | 2311 | 27°14'28.77 | 88°22'12.62 | N | Mild | 20 |
| RRF 29 | Moderate Wet temperate | 1827 | 27°16'53.00 | 88°20'36.35 | W | Mild | 45 |
| RRF 30 | Moderate Wet temperate | 1826 | 27°16'53.19 | 88°20'36.77 | W | 10 | 20 |
| RRF 31 | Moderate Wet temperate | 1816 | 27°16'56.30 | 88°20'34.30 | W | 15 | 20 |
| RRF 32 | Moderate Wet temperate | 1938 | 27°16'43.10 | 88°20'46.64 | NE | 15 | 40 |
| RRF 33 | Dense Wet temperate | 1947 | 27°16'35.90 | 88°20'41.75 | NE | 35 | 60 |
| RRF 34 | Moderate Wet temperate | 1961 | 27°16'32.73 | 88°20'33.11 | W | Mild | 40 |
| RRF 35 | Dense Wet temperate | 1961 | 27°16'32.78 | 88°20'32.97 | E | 25 | 60 |
| RRF 36 | Moderate Wet temperate | 1939 | 27°16'30.75 | 88°20'25.73 | E | 30 | 20 |
| RRF 37 | Dense Wet temperate | 1910 | 27°16'37.47 | 88°20'19.44 | E | 45 | 70 |
| RRF 38 | Dense Wet temperate | 1994 | 27°16'29.24 | 88°20'16.93 | NE | 35 | 60 |
| RRF 39 | Moderate Wet temperate | 1946 | 27°16'28.34 | 88°20'06.57 | N | 25 | 40 |
| RRF 40 | Dense Wet temperate | 1947 | 27°16'27.68 | 88°20'04.90 | E | 45 | 60 |
| RRF 41 | Dense Wet temperate | 1986 | 27°16'23.96 | 88°19'59.93 | E | 65 | 85 |
| RRF 42 | Moderate Wet temperate | 2005 | 27°16'21.22 | 88°19'56.38 | NE | 50 | 40 |
| RRF 43 | Dense Wet temperate | 1944 | 27°16'32.63 | 88°20'14.07 | E | 45 | 50 |
| RRF 44 | Moderate Wet temperate | 1880 | 27°16'37.62 | 88°20'15.39 | NE | 45 | 10 |
| Note: S: South; SE: South-East; NW: North-West; NE: North-East; N: North; W: West; SW: South-West; E: East | | | | | | | |

RESULTS AND DISCUSSION

Floristic Structure

During the survey, a total of 143 species were recorded during the field survey. Out of which 38 tree species (34 genera, 25 families), 47 herb species (35 genera, 23 families), 17 shrubs (14 genera in 11 families), 17 climbers (15 genera in 12 families), 15 ferns and fern-allies (12 genera in 9 families), 6 orchids (5 genera in 1 family) and 3 bamboos (2 genera in 1 family) are represented in **Table 35**.

| Habit | No. of species | Occurrence percentage (%) | Genus | Occurrence percentage (%) | Family | Occurrence percentage (%) |
|------------------------|----------------|---------------------------|------------|---------------------------|-----------|---------------------------|
| Trees | 38 | 26.57 | 34 | 29.06 | 25 | 30.49 |
| Shrubs | 17 | 11.89 | 14 | 11.97 | 11 | 13.41 |
| Herbs | 47 | 32.87 | 35 | 29.91 | 23 | 28.05 |
| Fern and fern-allies | 15 | 10.49 | 12 | 10.26 | 9 | 10.98 |
| Climbers and epiphytes | 17 | 11.89 | 15 | 12.82 | 12 | 14.63 |
| Orchids | 6 | 4.20 | 5 | 4.27 | 1 | 1.22 |
| Bamboo | 3 | 2.10 | 2 | 1.71 | 1 | 1.22 |
| Total | 143 | 100.00 | 117 | 100.00 | 82 | 100.00 |

Within the 44 plots, 109 floral species belonging to 92 genera (81 dicots, 15 monocots, 11 pteridophytes and 2 gymnosperms) and 58 families (44 dicots, 5 monocots, 7 pteridophytes and 2 gymnosperms) were recorded during the field survey (**Table 36**). Amongst the 109 species, 37 tree species (33 genera, 24 families), 32 herbs (27 genera, 18 families), 13 shrubs (11 genera, 9 families), 7 climbers and epiphytes (6 genera, 6 families), 6 orchids (5 genera, 1 family), 11 fern and fern allies (10 genera, 7 families) and 3 bamboo species (2 genera, 1 family) were recorded and are marked with (*) in **Annexure 6**.

| Plant Group | Species | % | Genera | % | Family | % |
|----------------|---|------------|-----------|------------|-----------|------------|
| Dicotyledons | 81 (35 trees, 26 herbs, 13 shrubs and 7 climbers/epiphytes) | 74.31 | 68 | 73.91 | 44 | 75.86 |
| Monocotyledons | 15 (3 bamboos, 6 orchids and 6 herbs) | 13.76 | 12 | 13.04 | 5 | 8.62 |
| Gymnosperms | 2 (2 trees) | 1.83 | 2 | 2.17 | 2 | 3.45 |
| Pteridophytes | 11 (ferns and fern-allies) | 10.09 | 10 | 10.87 | 7 | 12.07 |
| TOTAL | 109 | 100 | 92 | 100 | 58 | 100 |

Family Composition

From the family-wise analysis, amongst the 58 families, Rosaceae was the largest family represented by 7 species (6.48%) followed by Fagaceae, Urticaceae and Orchidaceae (6 sp. each, 5.56%). Among the trees, Fagaceae was the dominant family of 6 species (5.56%) representing *Castanopsis*, *Lithocarpus* and *Quercus* followed by Lauraceae (3 sp., 2.78%) representing *Actinodaphne sikkimensis*, *Beilschmiedia sikkimensis* and *Machilus*. Urticaceae (6 sp.), Asteraceae (6 sp.) and Polygonaceae (5 sp.) were the dominant families among herbs. Among the shrubs, the dominant family was Rosaceae representing 4 *Rubus* species (**Figure 39**). The presence of leading families reflects the main floristic composition of the biodiversity of the area while the families with small number reflect importance in the diversity of the species in the area.

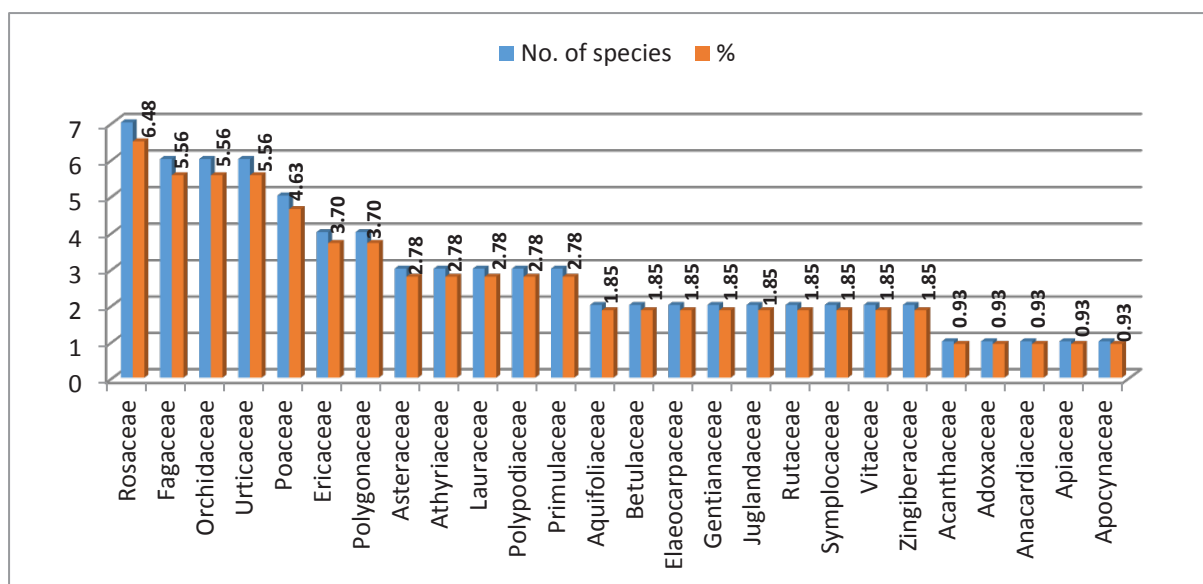


Figure 39: Major families of plant species and its occurrence

Family-wise analysis revealed that the maximum number of family belonged to dicotyledons (44, 76%) followed by pteridophytes (7, 12%), monocotyledons (5, 9%) and gymnosperms (2, 3%). The high percentage of dicotyledons is indicative of high speciation rate of the flower-bearing plants in the area (**Figure 40**).

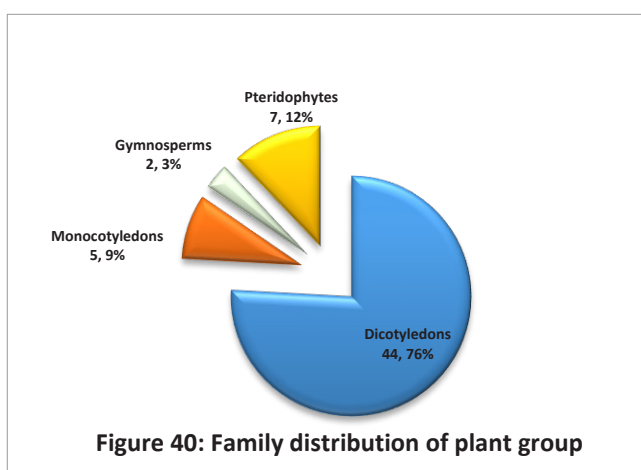


Figure 40: Family distribution of plant group

Life-form Spectra

In biological spectrum, the life form classes are represented by their percentages. Raunkier prepared a normal spectrum based on the sampling of world flora using one thousand entities. The normal spectrum has Phanerophytes 46%, Chamaephytes 9%, Cryptophytes 6%, Hemicryptophytes 26%, and Therophytes 13% based on the position of the perennating buds.

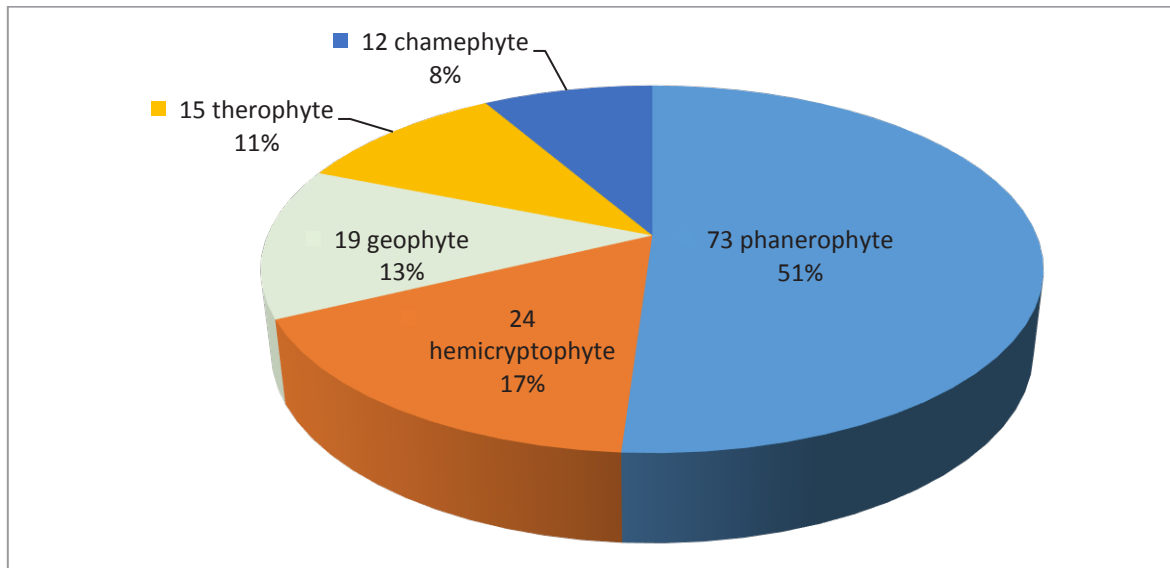


Figure 41: Life-form spectra of species

In the present study, all the 5 life forms were present in the area. Phanerophytes was the dominant life form in the temperate forest with the highest number of species (51.05% of 73 individuals) represented by woody trees and shrubs whose occurrence was regular throughout the forest. This was comparatively higher than the Raunkier's normal spectrum (46%). Hemicryptophytes with 16.78% (24 individuals) was represented by herbaceous perennial plants which were less compared to the normal spectrum (26%). This was followed by geophyte (13.29% of 19 individuals). The higher percentage of geophytes (which was much higher than the normal spectra) indicates the presence of rhizomatous plants is much higher in the region. The lowest life form in the region was that of chamaephytes represented by only 8.39% (**Figure 41**). The life forms of Rayong RF are comparatively diverse and on a higher side than the life form present in the temperate forest of Fambonglho Wildlife Sanctuary (Phanerophytes 44.7%, Hemicryptophytes 16.0%).

Species Density

Of the 37 large trees recorded in the sampling plots, the adult individuals of *Cryptomeria japonica* (181.81 ± 1.77 ind/ha) recorded the highest density followed by *Symplocos lucida* (100.00 ± 0.25 ind/ha) and *Symplocos glomerata* (68.18 ± 0.33 ind/ha). The lowest density (4.55 ± 0.00 ind/ha) was recorded for *Beilschmieda sikkimensis*, *Betula alnoides*, *Brassiopsis hispida*, *Garuga pinnata*, *Prunus bracteopadus* and *Toxicodendron hookeri* each. The adult density of *Magnolia doltsopa*, *Lyonia ovalifolia* and *Castanopsis hystrix* was however, recorded average in the forest with only 23 – 24 number of species and density of 54.55 ± 2.15 ind/ha, 52.28 ± 0.48 ind/ha and 52.27 ± 0.26 ind/ha, respectively.

The highest density for sapling and seedling was recorded for *Symplocos lucida* (181.82 ± 0.78 ind/ha and 220.45 ± 1.75 ind/ha), respectively. *Symplocos glomerata* was recorded with 22.73 ± 0.67 ind/ha sapling density and 113.64 ± 1.21 ind/ha seedling density. While the species with least sapling and seedling density (4.55 ± 0.00 ind/ha each) was for *Machilus* species and *Brassiopsis hispida* (Table 37).

Species Frequency

Frequency is a measure of the uniformity of the distribution of a species or the number of times a particular species occurs at a given unit. A low frequency indicates that a species is either irregularly distributed or rare in a particular stand or forest (Kharkwal & Rawat 2010). The high percentage frequency exhibited by the species denotes their wide range of niche preferences and capability to establish over a large area. In the temperate forest of the sampling path, the maximum frequency was recorded for *Symplocos lucida* (45.45%) followed by *Symplocos glomerata* (31.82%), *Castanopsis hystrix* (29.55%), *Cryptomeria japonica* and *Lyonia ovalifolia* (25% each). Medium frequencies were obtained for *Eurya acuminata* and *Quercus lamellosa* (18.18% each), *Castanopsis tribuloides* (15.91%), *Acer campbellii* and *Alnus nepalensis* (13.64% each). The lowest frequency of occurrence (4.55%) was observed for *Betula alnoides*, *Elaeocarpus lanceifolius*, *Juglans regia*, *Lithocarpus elegans*, *Prunus bracteopadus*, etc. The distribution of frequency of occurrence is shown in Table 37.

| Table 37: Availability and distribution of tree species in the sampling plots of Rayong Reserve Forest | | | | | | | | | |
|--|-----------------------|-------------------|--------|-------|--------|-----------------------|-----------------------|----------|--|
| Species Name | Adult | | | | | Sapling | | Seedling | |
| | Density (ind/Ha) ± SE | Species Abundance | F% | A/F | IVI | Density (ind/Ha) ± SE | Density (ind/Ha) ± SE | | |
| <i>Acer campbellii</i> | 13.63 ± 0.00 | 1.00 | 13.636 | 0.073 | 4.878 | 6.82 ± 0.50 | 38.64 ± 1.50 | | |
| <i>Actinodaphne sikkimensis</i> | 9.09 ± 1.00 | 2.00 | 4.545 | 0.440 | 1.593 | | | | |
| <i>Alnus nepalensis</i> | 43.18 ± 0.98 | 3.17 | 13.636 | 0.232 | 6.584 | | | | |
| <i>Beilschmiedia sikkimensis</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.100 | | | | |
| <i>Betula alnoides</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.109 | | | | |
| <i>Brassaiopsis hispida</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.093 | | 4.55 ± 0.00 | | |
| <i>Castanopsis hystrix</i> | 52.27 ± 0.26 | 1.77 | 29.545 | 0.060 | 12.322 | | 70.45 ± 1.30 | | |
| <i>Castanopsis tribuloides</i> | 40.90 ± 0.37 | 2.57 | 15.909 | 0.162 | 8.365 | 6.82 ± 0.50 | | | |
| <i>Cryptomeria japonica</i> | 181.81 ± 1.77 | 7.27 | 25.000 | 0.291 | 24.452 | | | | |
| <i>Echinocarpus dasycarpus</i> | 6.82 ± 0.00 | 1.00 | 6.818 | 0.147 | 1.832 | | | | |
| <i>Elaeocarpus lanceifolius</i> | 6.82 ± 0.50 | 1.50 | 4.545 | 0.330 | 1.546 | | | | |
| <i>Engelhardtia spicata</i> | 11.36 ± 0.33 | 1.67 | 6.818 | 0.244 | 2.294 | 9.09 ± 1.00 | 47.73 ± 1.39 | | |
| <i>Eurya acuminata</i> | 29.55 ± 0.38 | 1.63 | 18.182 | 0.089 | 5.986 | 15.91 ± 1.33 | 22.73 ± 0.89 | | |
| <i>Exbucklandia populnea</i> | 6.82 ± 0.50 | 1.50 | 4.545 | 0.330 | 1.450 | | | | |
| <i>Ficus neriifolia</i> | 11.36 ± 0.33 | 1.25 | 9.091 | 0.138 | 2.657 | | | | |
| <i>Garuga pinnata</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.210 | | | | |
| <i>Ilex sikkimensis</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.210 | | | | |
| <i>Juglans regia</i> | 11.36 ± 0.50 | 2.50 | 4.545 | 0.550 | 2.047 | | | | |
| <i>Leucoscepterum canum</i> | 6.82 ± 0.50 | 1.00 | 6.818 | 0.147 | 1.855 | | | | |

| | | | | | | | |
|----------------------------------|--------------|------|--------|-------|---------|---------------|---------------|
| <i>Lithocarpus elegans</i> | 6.82 ± 0.50 | 1.50 | 4.545 | 0.330 | 1.643 | 15.91 ± 1.50 | 18.18 ± 0.58 |
| <i>Lithocarpus pachyphyllus</i> | 45.45 ± 0.40 | 1.82 | 25.000 | 0.073 | 9.613 | | |
| <i>Lyonia ovalifolia</i> | 52.28 ± 0.48 | 2.09 | 25.000 | 0.084 | 10.013 | 18.18 ± 1.20 | |
| <i>Macaranga denticulata</i> | | | | | | | 9.09 ± 1.00 |
| <i>Machilus</i> sp. | 11.37 ± 0.25 | 1.25 | 9.091 | 0.138 | 2.886 | 4.55 ± 0.00 | 13.64 ± 2.00 |
| <i>Magnolia cathcartii</i> | | | | | | 9.09 ± 0.00 | 15.91 ± 1.50 |
| <i>Magnolia doltsopa</i> | 54.55 ± 2.15 | 4.80 | 11.364 | 0.422 | 8.127 | 6.82 ± 0.50 | 11.36 ± 0.50 |
| <i>Myrsine semiserrata</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.328 | | |
| <i>Prunus bracteopadus</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.470 | | |
| <i>Pyralia edulis</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.342 | | |
| <i>Quercus</i> sp. | 6.82 ± 0.50 | 1.50 | 4.545 | 0.330 | 1.648 | | |
| <i>Quercus lamellosa</i> | 40.91 ± 0.62 | 2.25 | 18.182 | 0.124 | 10.324 | 9.09 ± 1.00 | 9.09 ± 1.00 |
| <i>Rapanea capitellata</i> | 15.91 ± 0.75 | 1.75 | 9.091 | 0.193 | 3.552 | | |
| <i>Symplocos glomerata</i> | 68.18 ± 0.33 | 2.14 | 31.818 | 0.067 | 13.969 | 22.73 ± 0.67 | 113.64 ± 1.21 |
| <i>Symplocos lucida</i> | 100 ± 0.25 | 2.20 | 45.455 | 0.048 | 117.170 | 181.82 ± 0.78 | 220.45 ± 1.75 |
| <i>Toona sureni</i> | 6.82 ± 0.50 | 1.50 | 4.545 | 0.330 | 1.804 | | |
| <i>Toxicodendron hookeri</i> | 4.55 ± 0.00 | 1.00 | 4.545 | 0.220 | 1.576 | | |
| <i>Tsuga dumosa</i> | 13.64 ± 1.00 | 2.00 | 6.818 | 0.293 | 3.142 | 9.09 ± 0.00 | |
| Unidentified | 9.09 ± 0.33 | 1.33 | 6.818 | 0.196 | 63.636 | | |
| <i>Zanthoxylum acanthopodium</i> | 6.82 ± 0.50 | 1.5 | 4.545 | 0.330 | 6.324 | | |

Distribution Pattern

Distribution of species is one of the important aspects of ecological studies and individuals in a population may be distributed according to three broad patterns namely random, regular and contiguous. According to Odum (1971), contiguous distribution (>0.05) is the commonest pattern of species distribution in nature; random distribution ($0.025 - 0.05$) is found only in very uniform environment and where there is no tendency to aggregate; and regular distribution (<0.025) occurs where severe competition between the individuals exists. In general, higher frequency and lower abundance indicates regular distribution pattern while low frequency and high abundance indicates contiguous distribution. The ratio of abundance and frequency is a measure of contagiousness among plant population as formulated by Whitford (1948) and is widely accepted. In the present study, abundance to frequency ratio was observed for all the tree species showing contiguous distribution (97.30%) while only 1 species showed random distribution (2.70%) for *Symplocos lucida* but none of the species showed regular distribution (**Table 38**). The maximum abundance to frequency ratio of trees was observed for *Juglans regia* (0.55) followed by *Actinodaphne sikkimensis* (0.44), *Magnolia doltsopa* (0.42; **Table 37**). Subba *et al.* (2017) and Bharat *et al.* (2015b) also shows contiguous distribution of adult tree species except for *Acer caudatum* and *Cinnamomum impressinervium* which showed random distribution but none of the species showed regular distribution in the temperate forest.

| Distribution | No. of species | % of species |
|---------------------------|----------------|--------------|
| Regular (<0.025) | 0 | 0 |
| Random ($0.025 - 0.05$) | 1 | 2.70 |
| Contiguous (>0.05) | 36 | 97.30 |
| Total | 37 | 100 |

Importance Value Index (IVI)

Importance value is a measure of how dominant a species is in a given forest area and shows how ecologically important a species is in a given area. The concept of IVI has been developed for expressing the dominance and ecological success of any species with a single value (Misra 1968). The IVI depicts the phytosociological structure of a species in its totality in the community and used for prioritising species conservation whereby species with low IVI value need high conservation priority compared to the ones with high IVI (Zegeye 2006;

Kacholi 2013; Kacholi 2014). The IVI value is the sum of relative frequency, relative density and relative dominance and its value ranges from 0 to 300. For instance, a high value indicates that species A is well represented in the stand because of some combination of a large number of individuals of species A compared with other species in the stand or a smaller number of individuals of species A but the trees are large compared with others in the stand.

In the present study, the IVI values ranged between 1.093 and 117.170 (**Table 36**). The highest species in terms of IVI value in the temperate forest was recorded for *Symplocos lucida* (117.170). The other dominant species with high IVI values was recorded for *Cryptomeria japonica* (24.452), *Symplocos glomerata* (13.969) followed by *Castanopsis hystrix* (12.322), *Quercus lamellosa* (10.324), etc. The high IVI exhibited by *Symplocos lucida* is large due to its higher relative frequency (9.39), relative dominance (96.81) and high relative density (10.97) which indicates that this species was distributed frequently and relatively common along the transect making it an important species within the community. Hence, its IVI was maximum (Manohar 2015).

Species Diversity and Species Richness

Species diversity is the number of different species that are represented in a given community. It attributes to the functioning of an ecosystem by monitoring ecological change and the structure of a forest ecosystem. The species diversity depends on the number of species (species richness) and the evenness (number of individual species). It means the diversity not only determines the species present but also takes into account how many individual species are in a habitat and how evenly those species are distributed. Species diversity in a community is calculated using the Shannon – Weiner diversity index (Shannon & Weiner 1963). Species richness was calculated by using the ‘Margalef’s index of richness’ (Margalef 1958). Species evenness was determined by Shannon index of evenness.

In the present study, the sampled area of the temperate zone was comparatively rich in terms of tree richness ($I = 36.83$) and tree species diversity ($H' = 2.98$) as compared to the temperate forests of Barsey Rhododendron Sanctuary with species richness of $I = 32.5$ and species diversity of $H' = 2.36$, Lachung range ($I = 26.6$ and $H' = 2.29$) and Tholung – Kishong sampling path ($I = 18.8$ and $H' = 2.48$). The species diversity value for the temperate forests has reported to be between 0.83 and 4.1 which supports the value obtained in this study site (Subba *et al.* 2015; Parthasarthy *et al.* 1992; Singh *et al.* 1984; Visalakshi 1995). The high species diversity (Shannon index) value is indicative of high species richness and

the evenness equitability which leads to a higher community stability (MacArthur 1955; Dutta & Devi 2013). Also the presence of more species is directly related to the diversity of the species in the area (Table 39).

| Table 39: Species diversity and distribution of tree species in the temperate forest of Rayong RF | |
|---|-------|
| Diversity index (H') | 2.98 |
| Species Richness (I) | 36.83 |
| Species Evenness index (E) | 0.82 |

Shrubs

A total of 17 shrubs belonging to 15 genera and 12 families were recorded in the sampling plots. The frequency of occurrence value ranged between 2.3 and 86.4 while the percent cover ranged between 0.1 and 36.6. Of the 17 shrubs recorded from the sampling plots, *Viburnum erubescens* had widest availability in the area as it was present in 38 plots out of the 44 sampling plots. This species also showed the highest percent cover of 36.6% while its frequency of occurrence also showed highest value of 86.4% (Figure 42).

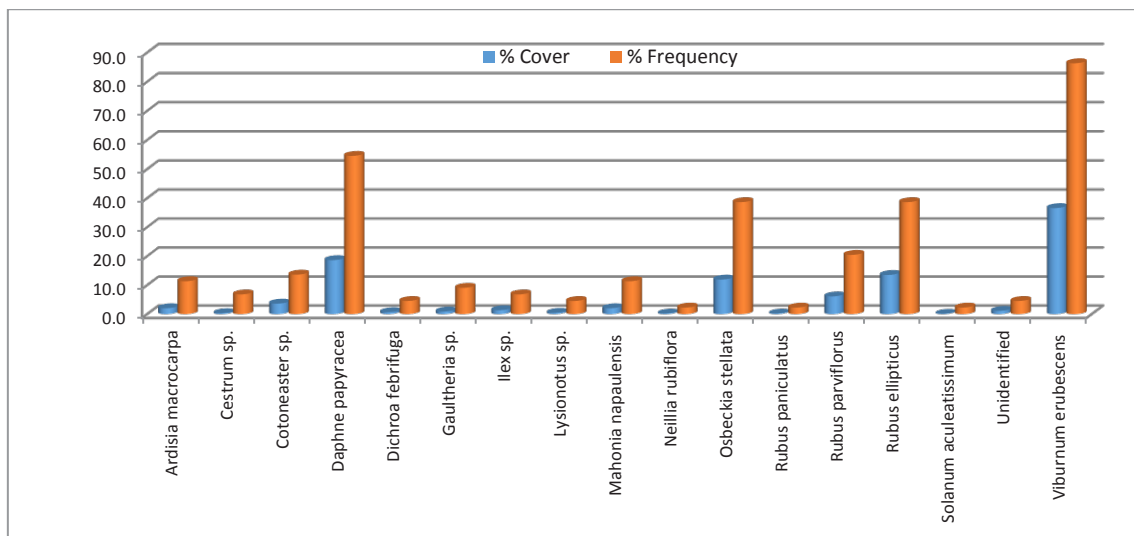


Figure 42: Status of shrubs in the sampling sites

Other species with wide availability in the site (from 17 plots) was of *Daphne papyracea* which showed the percent cover of 18.6% and frequency of occurrence of 54.5%. The low availability of species was *Solanum aculeatissimum*, *Rubus paniculatus* and *Neillia rubiflora* whose values of percent cover and frequency of occurrence ranged between 0.1 and 0.7%, respectively. These species were recorded only in single plot. In respect to number of species present in each plot majority of the plots had 3 or 4 species in a plot.

Herbs

A total of 44 herbs including the ferns and fern-allies were recorded in 44 sampling plots. These species belonged to 37 genera and 25 families. The frequency of occurrence value ranged between 2.3 and 59.1 while the percent cover ranged between 0.11 and 13.1. The maximum percent cover was recorded for *Selaginella* sp. (13.1%) followed by *Persicaria wallichii* (11.5%), *Gleichenia longissima* (9.6%) and *Eragrostis* sp. (8.3%) which indicates that these species are abundantly present in the sampling plots. However, the lowest percent cover was recorded for *Goniophlebium argutum*, *Gaultheria nummularioides* and *Belvisia henryi* with only 0.11% each. The highest frequency of occurrence was obtained for *Eragrostis* (59.1%) followed by *Carex* (56.8%), *Selaginella* (47.7%) and *Strobilanthes* (4.09%; **Figure 43**).

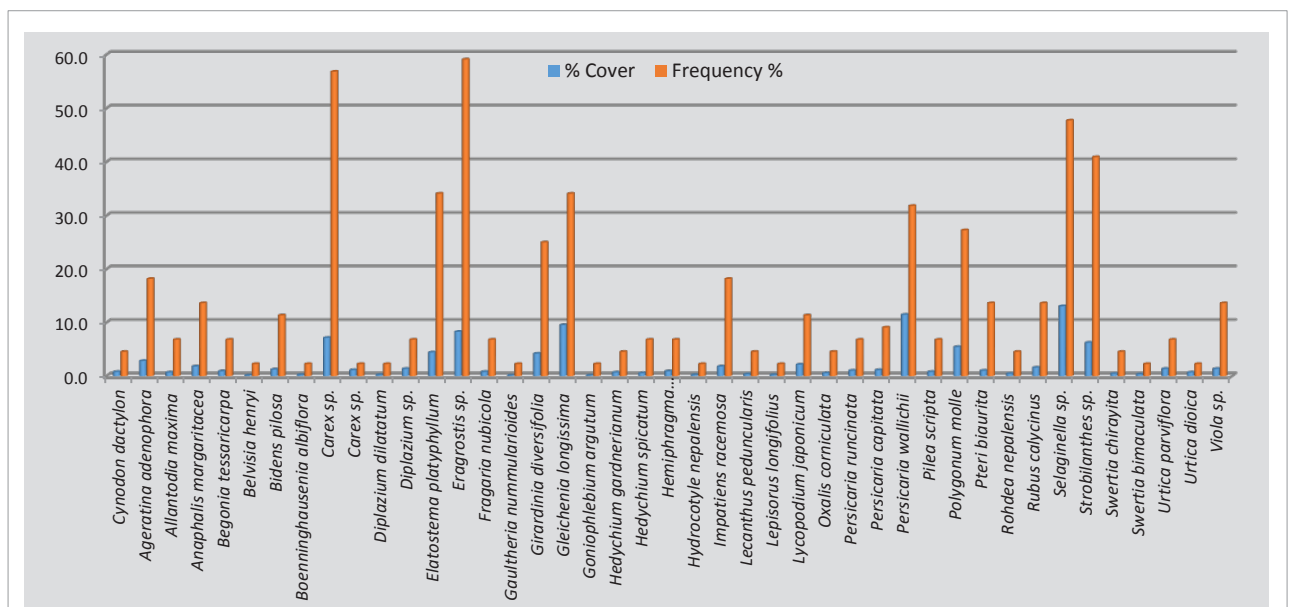


Figure 43: Status of herb species in the sampling sites

Other species had low frequency of occurrences ranging from 2.3% to 9.1%. In the family-wise analysis, the highest number of species belonged to the family Urticaceae (6 spp.), followed by Polygonaceae (4 spp.) and Athyriaceae, Asteraceae, Gentianaceae and Polypodiaceae (3 spp. each).

CONCLUSION AND RECOMMENDATION

Plant species is one of the most important characteristics of the plant community and varies from place to place. Density, basal area, size class and frequency distribution of trees contribute to the structure of the forest. During the survey, we recorded high density but low

frequency for adult individuals as compared to the density range obtained in the temperate forest of Tholung – Kishong (1.67ind/ha to 58.33ind/ha) but lower as compared to the density obtained in the temperate forests of Lachung Range (214.81ind/ha for *Picea spinulosa*) and Sang-Tinjure area of Fambonglho wildlife sanctuary (387.50ind/ha for *Castanopsis tribuloides*). The density for adult *Cryptomeria japonica* had high density as was the case for other adult trees. Such high density of the species could be due to that fact that it grows well in a habitat of deep, well-drained soil on warm and moist conditions as was the case found in the plots from 15 – 25 (2167m – 2279m) but in low frequency. This species is an exotic species from Japan and extensively planted in the forests of South Sikkim along Temi Tarku – Damthang – Tendong – Bhanjyang – Ravangla – Maenam forests as is in the Rayong RF. Such greater values of density are significant as they show importance of each species and with increasing density, the competition stress increases as is reflected in this study. However, the low occurrence of frequency suggests that most of the species in the forest are irregularly distributed or rare in a particular stand (Kharkwal & Rawat 2010).

During the survey in the sampling plots, 109 floral species belonging to 92 genera (81 dicots, 15 monocots, 11 pteridophytes and 2 gymnosperms) and 58 families (44 dicots, 5 monocots, 7 pteridophytes and 2 gymnosperms) were recorded which is a good floral composition in such a temperate forest. The presence of the dominant Fagaceae family in the area suggests that the presence of oak species contributes to a healthy forest ecosystem. Other leading families indicate that the species belonging to these families form an important composition of the biodiversity of the area. The presence of leading families reflects the main floristic composition of the biodiversity of the area while the families with small number reflect importance in the diversity of the species in the area.

In the present study, the sampled area of the temperate zone was comparatively rich in terms of tree richness ($I = 36.83$) and tree species diversity ($H' = 2.98$) as compared to the temperate forests of Barsey Rhododendron Sanctuary with species richness of $I = 32.5$ and species diversity of $H' = 2.36$, Lachung range ($I = 26.6$ and $H' = 2.29$) and Tholung – Kishong sampling path ($I = 18.8$ and $H' = 2.48$). The species diversity value for the temperate forests has reported to be between 0.83 and 4.1 which supports the value obtained in this study site (Subba *et al.* 2015; Parthasarthy *et al.* 1992; Singh *et al.* 1984; Visalakshi 1995). The high species diversity (Shannon index) value is indicative of high species richness and the evenness equitability which leads to a higher community stability (MacArthur 1955;

Dutta & Devi 2013). Also the presence of more species is directly related to the diversity of the species in the area. The high species diversity is a natural occurrence at this altitude of temperate forest as the vegetation composition is more diverse and there is more number of species than that at higher altitude. Saplings and seedlings of *Lithocarpus* and *Symplocos* are widely dispersed indicating good regeneration of the species in the forest.

The highest IVI value in the temperate forest recorded for *Symplocos lucida* (117.17) is large due to its higher relative frequency (9.39), relative dominance (96.81) and high relative density (10.97) which indicates that this species was distributed frequently and relatively common along the transect making it an important species within the community. Hence, its IVI was maximum (Manohar 2015). This also indicates that this species is an important species within the community. However, the low IVI values of species in the study area indicate that such species are rare in the forest and distributed irregularly and hence, need high conservation priority compared to the ones with high IVI.

Life form of any plant type is determined by the differences in temperature or precipitation, or the environment they adapt to. Since each life form is related to the environment, the biological spectrum is direct indicator of its environment. The presence of the highest occurring phanerophytes in the study site shows that this dominant life form in the temperate forest has the highest number of species (51.05% of 73 individuals) represented by woody trees and shrubs whose occurrence was regular throughout the forest. The higher percentage of geophytes (which was much higher than the normal spectra) indicates the presence of rhizomatous plants is much higher in the region. The absence of other life forms like heliophytes and hydrophytes indicates that the region lacks landform of water bodies and the absence of harsh condition for therophytes as the forest type of this region is temperate. These life forms give the structural diversity of the forest and are important from the ecological point of view.

In the present study, abundance to frequency ratio was observed for all the tree species showing contiguous distribution (97.30%) while only 1 species showed random distribution (2.70%) for *Symplocos lucida* but none of the species showed regular distribution.

According to the Forest Survey of India, trees of CBH 20 – 26 feet are demarcated as heritage trees. As per the survey, the forest hold significance in terms of the forest being a home to heritage trees of some oak species of evergreen *Castanopsis hystrix* with CBH of

20ft (609.6cm) recorded in plot 3 (1947 – 2202m) and *Quercus lamellosa* with CBH of 26ft (792.48cm) recorded in plot 23(2231m). Saplings and seedlings of *Lithocarpus* and *Symplocos* genus are widely dispersed indicating good regeneration of the species in the forest. However, their vast vegetation indicates the presence of the vulnerable Himalayan Black Bear as they feed on the fruits of these trees.

Only 5 individuals of *Juglans regia* was encountered and recorded into two plots 41 and 42 with girth size of 87 – 160 cm. Such species needs immediate attention in conserving the tree for further regeneration and for providing future prospects both in terms of forest conservation and medicinal purpose.

The view point area at 2374m is a fire prone area that was completely destroyed in the past. However, this area has been regenerated with various floral species such as *Carex* species (salimo), *Cyanodon* species and trees such as *Symplocos* species and *Lyonia ovalifolia* whose barks were terribly destroyed at the time. Pure stands of *Lyonia ovalifolia* can be found regenerated here. Amazingly, this particular area is a butterfly zone where a number of varied butterflies can be seen which can be helpful for lepidopterist. Also, it is a habitat for Goral which is considered as Near Threatened as per the IUCN. This is one area in the entire forest with a view point or a resting place from where the beautiful Mount Khanchengdzonga can be witnessed. Maenam wildlife sanctuary and the adjacent area are supposedly to be one of the hotspots of Fire-tailed myzornis and this is the only area where this bird has been sighted in our survey so far. So this area naturally becomes a hotspot for the species posing significance of the forest.

It may be concluded that the community study exhibited high diversity of plant species with high IVI and high species richness even though there occurs some rarity and uneven distribution of some species in regard to trees.

| Annexure 1: Checklist of floral species recorded along the sampling path of Assam Reserve Forest, East Sikkim | | | |
|---|--|----------------|---|
| Sl. No | Botanical Name | Family | Common Name |
| Large and small tree species | | | |
| 1 | * <i>Acer campbellii</i> Hook. & Thom.ex.Hiern. | Aceraceae | Kapasay |
| 2 | * <i>Acer caudatum</i> Wallich. | Aceraceae | Kapasey |
| 3 | * <i>Acer pectinatum</i> Wall. | Aceraceae | Lek kapasay |
| 4 | <i>Actinodaphne sikkimensis</i> Meissn. | Lauraceae | Phurkey sissi |
| 5 | * <i>Alangium begoniaefolium</i> (Roxb.) Baill | Alangiaceae | Akhanay |
| 6 | <i>Alnus nepalensis</i> D. Don. | Betulaceae | Utis |
| 7 | <i>Antidesma acuminatum</i> Wight | Euphorbiaceae | Lekh bilaune |
| 8 | * <i>Beilschmiedia sikkimensis</i> King exHook.f. | Lauraceae | Tarsing |
| 9 | * <i>Betula alnoides</i> Wall. ex Diels | Betulaceae | Saur |
| 10 | * <i>Brassaiopsis mitis</i> C.B.Clarke | Araliaceae | Phutta |
| 11 | * <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. | Fagaceae | Patley katush |
| 12 | * <i>Castanopsis indica</i> (Roxb.ex Lindl.) A.DC. | Fagaceae | Dhalne kattus |
| 13 | * <i>Castanopsis tribuloides</i> (Smith) A. DC. | Fagaceae | Musrey katus |
| 14 | <i>Cedrela febrifuga</i> Blume. | Meliaceae | Tuni |
| 15 | * <i>Cinnamomum obtusifolium</i> Nees. | Lauraceae | Bhaley sinkoli |
| 16 | * <i>Cryptomeria japonica</i> (Thunberg ex. Linn. F.) D. Don | Taxodiaceae | Dhuppi |
| 17 | * <i>Daphniphyllum himalayense</i> (Benth.) Mull. Arg. | Euphorbiaceae | Lal chandan |
| 18 | * <i>Elaeocarpus lanceaefolius</i> Roxburgh. | Elaeocarpaceae | Bhadrasesy |
| 19 | * <i>Engelhardtia spicata</i> Blume | Juglandaceae | Mauwa |
| 20 | * <i>Erythrina arborescens</i> Roxb | Leguminosae | Phaledo |
| 21 | * <i>Eurya acuminata</i> DC. | Theaceae | Jhingni |
| 22 | * <i>Exbucklandia populnea</i> R. Br. Ex Griff | Hamamelidaceae | Piplee |
| 23 | <i>Ficus hookeri</i> Miq. | Moraceae | Nebharo |
| 24 | * <i>Ficus nemoralis</i> Wall. | Moraceae | Dudilo |
| 25 | * <i>Garuga pinnata</i> Roxb. | Burseraceae | Dabdabay |
| 26 | <i>Glochidion acuminatum</i> Muell. | Euphorbiaceae | Latikaath |
| 27 | <i>Gynocardia odorata</i> Roxburgh | Flacourtiaceae | Bandre/Gante |
| 28 | * <i>Hovenia dulcis</i> Thunb. | Thymelaeaceae | Bangi |
| 29 | * <i>Juglans regia</i> Linn. | Juglandaceae | Okhar |
| 30 | * <i>Leucosceptrum cannum</i> Smith | Lamiaceae | Ghurpis |
| 31 | <i>Lithocarpus fenestrata</i> Roxb. | Fagaceae | Arkaulo |
| 32 | <i>Litsea kingii</i> Hook. | Lauraceae | Siltimmur |
| 33 | * <i>Macaranga pustulata</i> King. | Euphorbiaceae | Malato |
| 34 | * <i>Machilus edulis</i> King. | Lauraceae | Pumsee / Funchey |
| 35 | * <i>Machilus gamblei</i> King ex J. D. Hooker | Lauraceae | Ghew Kaulo / Lapche Kaulo / Chiplay Kaulo |
| 36 | <i>Machilus gammieana</i> King ex. Hook. f. | Lauraceae | Kawla |

| | | | |
|------------------------------------|---|----------------|---------------------------------|
| 37 | <i>Machilus odoratissimus</i> Nees | Lauraceae | Ghew funchey |
| 38 | <i>Maesa chisia</i> Buch.-Ham. ex D. Don | Myrsinaceae | Bilaune |
| 39 | * <i>Magnolia cathcartii</i> (Hook.f. & Thomson) Noot. | Magnoliaceae | Tite champ |
| 40 | * <i>Magnolia doltsopa</i> (Buch.-Ham. ex DC.) Figlar | Magnoliaceae | Rani champ |
| 41 | <i>Myrica esculenta</i> Buch. Ham. | Myricaceae | Kafal |
| 42 | <i>Myrsine semiserrata</i> Wall. | Myrsinaceae | Phalame |
| 43 | * <i>Nyssa sessiliflora</i> Hook. f. & Thomson ex Benth | Cornaceae | Lek chilauney |
| 44 | <i>Ostedes paniculatus</i> Blume. | Euphorbiaceae | Bepari |
| 45 | <i>Pieris ovalifolia</i> D. Don | Ericaceae | Angari |
| 46 | <i>Prunus cerasoides</i> Don. | Rosaceae | Paiyun |
| 47 | * <i>Prunus nepalensis</i> (Ser) Stendel | Rosaceae | Arupatey |
| 48 | <i>Pyrularia edulis</i> (Wallich) A. | Santalaceae | Amphi |
| 49 | * <i>Quercus lamellosa</i> Smith. | Fagaceae | Buk/ Bajranth |
| 50 | * <i>Quercus pachyphylla</i> Kurz. | Fagaceae | Sungure katus/ Bantay/ Oitay |
| 51 | * <i>Rhododendron arboreum</i> ssp. <i>arboreum</i> (CB Clarke) Ridley. | Ericaceae | Lali gurans |
| 52 | * <i>Rhododendron barbatum</i> Wall ex. G.Don | Ericaceae | Lal Chimal |
| 53 | * <i>Rhododendron falconeri</i> Hook.f. | Ericaceae | Korlinga |
| 54 | * <i>Rhododendron grande</i> Wright. | Ericaceae | Patle korlinga |
| 55 | * <i>Rhus succedanea</i> Linn. | Anacardiaceae | Bhalayo |
| 56 | <i>Rhus succedanea</i> Linn.var. <i>acuminata</i> | Anacardiaceae | Rani bhalayo |
| 57 | <i>Schima wallichii</i> (DC) Korth. | Theaceae | Chilaune |
| 58 | <i>Spondias axillaris</i> Roxb. | Anacardiaceae | Lapsi |
| 59 | * <i>Symingtonia populnea</i> (R. Br. Ex Griff.) | Hamamelidaceae | Piple |
| 60 | * <i>Symplocos glomerata</i> King, ex. C.B. Clarke | Symplocaceae | Kholme |
| 61 | * <i>Symplocos theifolia</i> Don. | Symplocaceae | Kharanay |
| 62 | * <i>Tetradium fraxinifolium</i> (Hook.) Hartley | Rutaceae | Khanakpa |
| 63 | <i>Tetrameles nudiflora</i> R.Br. | Tetramelaceae | Mayna |
| 64 | <i>Callicarpa arborea</i> Roxb. | Lamiaceae | Guenlo |
| 65 | <i>Zanthoxylum acanthopodium</i> DC | Rutaceae | Boke timur |
| 66 | <i>Wrightia gigantia</i> | Apocynaceae | Bauni kath |
| 67 | Unidentified | Fagaceae | |
| Shrub and shrub-let species | | | |
| 1 | * <i>Antidesma acuminatum</i> Wight | Myrsinaceae | Lel belaune |
| 2 | <i>Ardisia macrocarpa</i> Wall. | Myrsinaceae | Damai phal |
| 3 | * <i>Daphne papyraceae</i> Wall. | Thymeleaceae | Kalo argeli/Kagate |
| 4 | * <i>Dichroa febrifuga</i> Lour | Hydrangeaceae | Basak |
| 5 | * <i>Edgeworthia gardenierii</i> Meissn. | Thymeliaceae | Argali |
| 6 | <i>Eupatorium adenophorum</i> Sprengel | Asteraceae | Kalijhar |
| 7 | <i>Eurya acuminata</i> | Theaceae | Jhiganey |

| | | | |
|---------------------|--|-----------------|--------------------------|
| 8 | <i>Hypericum oblongifolium</i> Choisy | Hypericaceae | Urilo |
| 9 | <i>Leucosceptrum</i> sp. | Lamiaceae | Ghurpis |
| 10 | * <i>Maesa chisia</i> Don | Myrsinaceae | Bilauney |
| 11 | <i>Mahonia napaulensis</i> DC | Berberidaceae | Chutro |
| 12 | <i>Massaenda ruxbughii</i> | Rubiaceae | Dhobini phul |
| 13 | <i>Neillia rubiflora</i> D.Don | Rosaceae | Khareto jhar |
| 14 | <i>Osbeckia stellata</i> | Melastomataceae | Rato chulesi |
| 15 | * <i>Oxyspora paniculata</i> (D.Don) DC | Melastomataceae | Chulesi |
| 16 | <i>Polygala arillata</i> Buch.- Ham ex D.Don. | Polygalaceae | Marcha jhar |
| 17 | * <i>Rubus ellipticus</i> Smith. | Rosaceae | Aiselu |
| 18 | <i>Rubus niveus</i> Thunb | Rosaceae | Aiselu / Biralu kanra |
| 19 | <i>Rubus paniculatus</i> (Smith) Rees. | Rosaceae | Kalo Aiselu |
| 20 | * <i>Viburnum erubescens</i> Wallich ex DC | Sambucaceae | Asaray |
| 21 | <i>Gaultheria fragrantissima</i> Wall. | Ericaceae | Dhasingarey |
| 22 | <i>Gaultheria nummularioides</i> D.Don | Ericaceae | Kaligedi |
| 23 | Unidentified | | Patpatay (Yellow flower) |
| 24 | Unidentified | | Seti kath |
| Herb species | | | |
| 1 | <i>Aconogonum campanulatum</i> (Hook.f.) Hara | Polygonaceae | Kukur thotnay |
| 2 | <i>Aconogonum molle</i> D. Don | Polygonaceae | Thotnay |
| 3 | <i>Acorus calamus</i> Linn. | Acoraceae | Bojo |
| 4 | <i>Aeschynanthus parviflorus</i> (D.Don) Spreng. | Gesneriaceae | Baklay patay |
| 5 | <i>Aeschynanthus hookeri</i> C.B.Clarke | Gesneriaceae | Baklay patay |
| 6 | <i>Ampelocissus latifolia</i> (Roxb.) Planch | Vitaceae | Pani lahara |
| 7 | <i>Anaphalis triplinervis</i> C.B. Clarke | Asteraceae | Bukey Phool |
| 8 | <i>Arisaema intermedium</i> Blume | Araceae | Larua/Banko |
| 9 | <i>Arisaema flavum</i> (Forsskal) Schott | Araceae | Sap ko makai |
| 10 | <i>Arisaema speciosum</i> (Wall.) Mart. | Araceae | Sap ko Makai |
| 11 | <i>Artemisia vulgaris</i> Linn. | Asteraceae | Titaypati |
| 12 | <i>Astilbe rivularis</i> Ham | Saxifragaceae | Burokhathi |
| 13 | <i>Begoniapicta</i> Sm. | Asteraceae | Magar kanje |
| 14 | <i>Boehmeria platyphylla</i> D.Don | Urticaceae | Kamley |
| 15 | <i>Campylandra aurantiaca</i> Baker | Asparagaceae | Jangali nakima |
| 16 | <i>Carex</i> sp. | Cyperaceae | Harkatto |
| 17 | <i>Cautleya spicata</i> – (J. M. Sm.) Bak | Zingiberaceae | Sara |
| 18 | <i>Centella asiatica</i> (L.) Urban | Umbelliferae | Golpatta |
| 19 | <i>Commelina benghalensis</i> L. | Commelinaceae | Kanay |
| 20 | <i>Crawfordia</i> sp. | Gentianaceae | |
| 21 | <i>Cyanotis vaga</i> (Loour.) Roem & Schult. | Commelinaceae | Kanay |
| 22 | <i>Cynodon dactylon</i> Linn | Poaceae | Dubo |

| | | | |
|----|--|-----------------|--------------------------------|
| 23 | <i>Digitaria sanguinalis</i> (Linn.) Scopoli. | Poaceae | Banso |
| 24 | <i>Drymaria cordata</i> Wild. ex. Roem & Schult. | Caryophyllaceae | Abhijalo |
| 25 | <i>Elatostema platyphyllum</i> Weddell. | Urticaceae | Gagleto |
| 26 | <i>Elatostema sessile</i> J.R.Forst. & G.Forst. | Urticaceae | Gagleto |
| 27 | <i>Eragrostis cilianensis</i> (All.) Lut. ex | Poaceae | Banso |
| 28 | <i>Eupatorium adenophorum</i> Spreng. | Asteraceae | Kali jhar |
| 29 | <i>Fragaria nubicola</i> Lindley ex. Lacaita | Rosaceae | Bhui-aiselu |
| 30 | <i>Gerardiana diversifolia</i> (Link) Friis | Urticaceae | Bhangre sisnu |
| 31 | <i>Globba clarkei</i> Baker | Zingiberaceae | |
| 32 | <i>Hedychium spicatum</i> | Zingiberaceae | Gai sara |
| 33 | <i>Hedychium gracile</i> Roxb. | Zingiberaceae | Sara |
| 34 | <i>Hemiphragma heterophyllum</i> Wall. | Plantaginaceae | Nash jhar |
| 35 | <i>Houttuynia cordata</i> Thunb | Saururaceae | Raktha-jhar |
| 36 | <i>Impatiens stenantha</i> Hook. f. | Balsaminaceae | Mujuro |
| 37 | <i>Impatiens urticifolia</i> Wallich | Balsaminaceae | Mujuro |
| 38 | <i>Lecanthus peduncularis</i> (Wall. ex Royle) Wedd. | Urticaceae | Gagleto |
| 39 | <i>Osbeckia stellata</i> Hook.f | Melastomataceae | Arbal |
| 40 | <i>Oxalis corniculata</i> Linn. | Oxalidaceae | Chariamilo |
| 41 | <i>Persicaria capitata</i> (Buch.- Ham. ex D.Don) H. Gross | Polygonaceae | Ratnaulo |
| 42 | <i>Pilea stricta</i> (Buchanan-Hamilton ex D. Don) Weddell | Urticaceae | Chiple |
| 43 | <i>Pilea umbrosa</i> Blume. | Urticaceae | Chiple |
| 44 | <i>Pouzolzia sanguine</i> (Blume) Merrill | Urticaceae | Chiple |
| 45 | <i>Rumex nepalensis</i> Spreng. | Polygonaceae | Halhalley |
| 46 | <i>Selaginella biformis</i> A. Br. ex Kuhn | Selaginellaceae | Jhew |
| 47 | <i>Selaginella chrysocaulos</i> (Hook. & Grev.) Spring. | Selaginellaceae | Jhew |
| 48 | <i>Selaginella monospora</i> Spring. | Selaginellaceae | Jhew |
| 49 | <i>Smilax</i> sp. | Smilacaceae | Madaney kara / Kirney ghans |
| 50 | <i>Strobilanthes</i> sp. | Acanthaceae | Kibu ghans |
| 51 | <i>Swertia bimaculata</i> (Roxb. ex Flem.) Karsten | Gentianaceae | Bhaley chiraito |
| 52 | <i>Swertia chirayita</i> H. Karsten | Gentianaceae | Chiraito |
| 53 | <i>Urtica dioica</i> Linn. | Urticaceae | Patley sisnu |
| 54 | <i>Urtica parviflora</i> Roxburgh | Urticaceae | Gharia sisnu |
| 55 | <i>Villebrunea frutescens</i> (Thunb.) Blume | Urticaceae | Chiple |
| 56 | <i>Viola sikkimensis</i> W. Becker | Violaceae | Silamey jhar |
| 57 | <i>Hedychium</i> sp. | Zingiberaceae | Qiura |
| 58 | <i>Heracleum wallichii</i> DC. | Umbelliferae | Chimphing |
| 59 | <i>Digitaria ciliaris</i> (Retzius) Koeler | Poaceae | Chitray Banso |
| 60 | <i>Holboellia angustifolia</i> Diels. | Lardizabalaceae | Gulfa |
| 61 | <i>Stephania glabra</i> (Roxb.) Mier | Menispermaceae | Tambarkay |
| | | | |

| Epiphyte / Climber species | | | |
|--------------------------------|--|------------------|-------------------------|
| 1 | <i>Aconogonum molle</i> (D. Don) H. Hara | Polygonaceae | Thotne |
| 2 | <i>Arisaema intermedium</i> Blume | Araceae | Larua/Banko |
| 3 | <i>Boehmeria</i> sp. | Urticaceae | Kamley |
| 4 | <i>Cardamine hirsuta</i> L. | Brassicaceae | Titey |
| 5 | <i>Carex</i> sp. | Cyperaceae | Harkatto |
| 6 | <i>Clematis acuminata</i> DC | Ranunculaceae | Pinasay lahara |
| 7 | <i>Clematis buchananiana</i> DC. | Ranunculaceae | Pinasey lahara |
| 8 | <i>Codonopsis viridis</i> Wallich. | Campanulaceae | Padey lahara |
| 9 | <i>Coelogyne flaccida</i> (Lindl.) Kuntz. | Orchidaceae | Sunakhari |
| 10 | <i>Davallodes membranulosa</i> (Hook.) Copel. | Davalliaceae | Uniu |
| 11 | <i>Digitaria sanguinalis</i> (Linn.) Scopoli. | Poaceae | Banso |
| 12 | <i>Diplazium dilatatum</i> Blume Lek | Woodsiaceae | ChipleY Ningro |
| 13 | <i>Diplazium stoliczkae</i> Beddome | Woodsiaceae | Lek kalo ningro |
| 14 | <i>Elatostema platyphyllum</i> Weddell. | Urticaceae | Gagleto |
| 15 | <i>Eragrostis cilianensis</i> (All.) Lut. ex Janchen | Poaceae | Banso |
| 16 | <i>Galium</i> sp. | Rubiaceae | - |
| 17 | <i>Machilus gamblei</i> King ex J. D. Hooker | Lauraceae | Seti kaulo / Ghew kaulo |
| 18 | <i>Mucuna macrocarpa</i> Wall. | Leguminosae | Baldengra |
| 19 | <i>Pleione praecox</i> (Lindl.) | Orchidaceae | - |
| 20 | <i>Piper</i> sp. | Piperaceae | |
| 21 | <i>Piper boehmeriaefolia</i> (Miq.) DC. | Piperaceae | Chabo / Jungali pan |
| 22 | <i>Rhapidiphora decursiva</i> (Roxb.) Schott. | Araceae | Kanchirno |
| 23 | <i>Rubia cordifolia</i> Linn. | Rubiaceae | Majito |
| 24 | <i>Smilax zeylanica</i> Linn. | Liliaceae | Kukur dainey |
| 25 | <i>Smilax aspara</i> L. | Liliaceae | Kukur daina |
| 26 | <i>Tetrastigma serrulatum</i> (Roxb.) Planchon | Vitaceae | Charcharey lahara |
| 27 | <i>Trichosanthes lepiniana</i> (Naud.) Cogn. | Cucurbitaceae | Indreni |
| 28 | <i>Viscum articulatum</i> Burm. f. | Lorantahceae | Harchur |
| 29 | <i>Wrightia gigantea</i> | Apocynaceae | Bauni kath |
| Ferns and fern- allies species | | | |
| 1 | <i>Asplenium laciniatum</i> D. Don. | Aspleniaceae | Uniu |
| 2 | <i>Blechnum orientale</i> L. | Blechnaceae | Deer Fern |
| 3 | <i>Coniogramme intermedia</i> Heiron. | Pteridaceae | Uniu |
| 4 | <i>Coniogramme fraxinea</i> (D. Don) Fee ex Diels | Pteridaceae | Bamboo leaf fern |
| 5 | <i>Cyathea spinulosa</i> Wall. ex Hook | Cyatheaceae | Rukh uniu |
| 6 | <i>Dennstaedtia appendiculata</i> (Wall. ex Hook.) J. Sm | Dennstaedtiaceae | Piray uniu |
| 7 | <i>Diplazium dilatatum</i> Blume | Woodsiaceae | Lek chipleY ningro |
| 8 | <i>Diplazium esculentum</i> (Retz.) Sw | Woodsiaceae | Chiplay ningro |
| 9 | <i>Diplazium stoliczkae</i> Beddome | Woodsiaceae | Lek kalo ningro |

| | | | |
|------------------------------|--|-----------------|----------------|
| 10 | <i>Drynaria</i> sp. | Polypodiaceae | Basket fern |
| 11 | <i>Equisetum diffusum</i> D.Don. | Equiaetaceae | Salli bisalli |
| 12 | <i>Gleichenia gigantean</i> Wall. ex Hook | Dryopteridaceae | Kalamey Uniu |
| 13 | <i>Gleichenia longissima</i> Blume | Dryopteridaceae | Sottarey uniu |
| 14 | <i>Lepisorus</i> sp. | Polypodiaceae | Polypods |
| 15 | <i>Leucostegia truncata</i> (D.Don) Fras.-Jenk. | Davalliaceae | Deer fern |
| 16 | <i>Lycopodium japonicum</i> Thunb | Lycopodiaceae | Nagbelli |
| 17 | <i>Monachosoram henryi</i> Christ. | Monachosoraceae | Uniu |
| 18 | <i>Microsorium membranaceum</i> (D.Don) Cing | Polypodiaceae | Uniu |
| 19 | <i>Nephrolepis cordifolia</i> (Linn.) C. Presl. | Davalliaceae | Pani amala |
| 20 | <i>Odontosoria chinensis</i> (L.) J.Smith | Lindsaeaceae | Uneu |
| 21 | <i>Plagiogyria pycnophylla</i> (Kunze.) Mett. | Plagiogyriaceae | Uniu |
| 22 | <i>Pseudodrynaria coronans</i> (Wall.ex Mett.) T.Moore | Polypodiaceae | Kamray lahara |
| 23 | <i>Pteridium revolutum</i> (Blume) Nakai | Pteridaceae | Uniu |
| 24 | <i>Pteris biaurita</i> L. | Pteridaceae | Uniu |
| 25 | <i>Pteris wallichiana</i> J. Agardh | Pteridaceae | Uneu |
| 26 | <i>Vittaria elongata</i> Sw | Vittariaceae | Uniu |
| Bamboo / Cane species | | | |
| 1 | <i>Costus speciosus</i> Koenig Sm. | Costaceae | Bethlauri |
| 2 | * <i>Themnocalamus falconeri</i> Hook.f. ex. Munro. | Poaceae | Singanay bans |
| 3 | * <i>Himalayacalamus hookerianus</i> (Munro) Stapleton | Poaceae | Pareng |
| 4 | <i>Phyllostachys aurea</i> Riviere & C.Rivire | Poaceae | Katha Bans |
| 5 | <i>Plectocomia himalayana</i> Giff. | Arecaceae | Fyakray bet |
| 6 | <i>Schizostachyum capitatum</i> (Munro) R.B.Majumdar | Poaceae | Gope Bans |
| 7 | <i>Sinarundinaria intermedia</i> (Munro) C.S.Chao & Renvoize | Poaceae | Nigalo/ Nigalo |
| 8 | <i>Themnocalamus falconeri</i> Hook.f. ex. Munro. | Poaceae | Singanay Bans |
| 9 | * <i>Yushania maling</i> (Gamble) R.B.Majumdar & Karthik. | Poaceae | Malingo |
| 10 | * <i>Drapenostachyun intermedium</i> (Munro.) Keng.f. | Poaceae | Titay nigalo |

Annexure 2: Checklist of floral species recorded along the sampling path of Barapathing Reserve Forest, East Sikkim

| Sl. No. | Botanical name | Family | Local name |
|--|--|----------------|---|
| Tree and small tree / Large shrub species | | | |
| 1 | * <i>Acer campbellii</i> Hook.f. & Thomson ex Hiern | Aceraceae | Kapasay |
| 2 | <i>Acer caudatum</i> Wallich. | Aceraceae | Kapasey |
| 3 | * <i>Acer pectinatum</i> Wall.ex G.Nicholson | Aceraceae | Lek Kapasay |
| 4 | <i>Actinodaphne sikkimensis</i> Meissn. | Lauraceae | Phurkey Sissi |
| 5 | * <i>Alangium begoniaefolium</i> (Roxb.) Baill | Alangiaceae | Akhanay |
| 6 | <i>Alnus nepalensis</i> D. Don. | Betulaceae | Utis |
| 7 | <i>Antidesma acuminatum</i> Wight | Euphorbiaceae | Lekh bilaune |
| 8 | <i>Betula alnoides</i> Wall. ex Diels | Betulaceae | Saur |
| 9 | * <i>Brassaiopsis mitis</i> C.B.Clarke | Araliaceae | Phutta |
| 10 | * <i>Beilschmiedia sikkimensis</i> King ex Hook.f. | Lauraceae | Tarsing |
| 11 | <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. | Fagaceae | Patley katush |
| 12 | <i>Castanopsis indica</i> (Roxb.ex Lindl.) A.DC. | Fagaceae | Dhalne kattus |
| 13 | * <i>Castanopsis tribuloides</i> (Smith) A. DC. | Fagaceae | Musrey katus |
| 14 | <i>Toona sureni</i> (Blume) Merr. | Meliaceae | Tuni |
| 15 | * <i>Cinnamomum impressinervium</i> Meisn. | Lauraceae | Sinkoli |
| 16 | <i>Cryptomeria japonica</i> (Thunberg ex. Linn. F.) D. Don | Taxodiaceae | Dhuppi |
| 17 | <i>Daphniphyllum himalayense</i> (Benth.) Mull. Arg. | Euphorbiaceae | Lal Chandan |
| 18 | * <i>Elaeocarpus lanceaefolius</i> Roxburgh. | Elaeocarpaceae | Bhadrasesy |
| 19 | <i>Engelhardtia spicata</i> Blume | Juglandaceae | Mauwa |
| 20 | * <i>Erythrina arborescens</i> Roxb | Leguminosae | Phaledo |
| 21 | * <i>Eurya acuminata</i> DC. | Theaceae | Jhingni |
| 22 | * <i>Exbucklandia populnea</i> R. Br. Ex Griff | Hamamelidaceae | Piplee |
| 23 | <i>Ficus hookeriana</i> Corner. | Moraceae | Nebharo |
| 24 | * <i>Ficus neriifolia</i> Sm. | Moraceae | Dudilo |
| 25 | * <i>Garuga pinnata</i> Roxb. | Burseraceae | Dabdabay |
| 26 | <i>Glochidion acuminatum</i> Muell. | Euphorbiaceae | Latikaath |
| 27 | <i>Gynocardia odorata</i> Roxburgh | Flacourtiaceae | Bandre/Gante |
| 28 | * <i>Hovenia dulcis</i> Thunb. | Thymelaeaceae | Bangi |
| 29 | <i>Juglans regia</i> Linn. | Juglandaceae | Okhar |
| 30 | * <i>Leucosceptrum cannum</i> Smith | Lamiaceae | Ghurpis |
| 31 | <i>Lithocarpus fenestrata</i> Roxb. | Fagaceae | Arkaulo |
| 32 | <i>Litsea kingii</i> Hook. | Lauraceae | Siltimmur |
| 33 | <i>Macaranga pustulata</i> King. | Euphorbiaceae | Malato |
| 34 | * <i>Machilus edulis</i> King. | Lauraceae | Pumsee / Funchey |
| 35 | * <i>Machilus gamblei</i> King ex J. D. Hooker | Lauraceae | Ghew Kaulo / Lapche Kaulo / Chiplay Kaulo |
| 36 | <i>Machilus gammieana</i> King ex. Hook. f. | Lauraceae | Kawla |
| 37 | <i>Machilus odoratissimus</i> Nees | Lauraceae | Ghew funchey |
| 38 | <i>Maesa chisia</i> Buch.-Ham. ex D. Don | Myrsinaceae | Bilaune |
| 39 | <i>Magnolia cathcartii</i> (Hook.f. & Thomson) Noot. | Magnoliaceae | Tite chanp |

| | | | |
|-----------------------------------|---|-----------------|---------------------------------|
| 40 | * <i>Magnolia doltsopa</i> (Buch.-Ham. ex DC.) Figlar | Magnoliaceae | Rani champ |
| 41 | * <i>Mahonia napaulensis</i> DC | Berberidaceae | Chutro |
| 42 | <i>Myrica esculenta</i> Buch. Ham. | Myricaceae | Kafal |
| 43 | <i>Myrsine semiserrata</i> Wall. | Myrsinaceae | Phalame |
| 44 | * <i>Nyssa sessiliflora</i> Hook. f. & Thomson ex Benth | Cornaceae | Lek chilauney |
| 45 | <i>Ostedes paniculatus</i> Blume. | Euphorbiaceae | Bepari |
| 46 | * <i>Pieris ovalifolia</i> D. Don | Ericaceae | Angari |
| 47 | <i>Prunus cerasoides</i> Don. | Rosaceae | Paiyun |
| 48 | <i>Prunus nepalensis</i> (Ser) Stendel | Rosaceae | Arupatey |
| 49 | <i>Pyrularia edulis</i> (Wallich) A. | Santalaceae | Amphi |
| 50 | * <i>Quercus glauca</i> Thunb. | Fagaceae | |
| 51 | * <i>Quercus lamellosa</i> Smith. | Fagaceae | Buk/ Bajranth |
| 52 | <i>Quercus pachyphylla</i> Kurz. | Fagaceae | Sungure Katus/ Bantay/ Oitay |
| 53 | * <i>Rapanea capitellata</i> (Wall.)Mez | Primulaceae | |
| 54 | <i>Rhododendron arboreum</i> ssp. <i>arboreum</i> (CB Clarke) Ridley. | Ericaceae | Lali gurans |
| 55 | * <i>Rhododendron falconeri</i> Hook.f. | Ericaceae | Korlinga |
| 56 | * <i>Rhododendron grande</i> Wright. | Ericaceae | Patle korlinga |
| 57 | <i>Rhus succedanea</i> Linn. | Anacardiaceae | Bhalayo |
| 58 | * <i>Rhus succedanea</i> Linn.var. <i>acuminata</i> | Anacardiaceae | Rani bhalayo |
| 59 | <i>Schima wallichii</i> (DC) Korth. | Theaceae | Chilaune |
| 60 | <i>Spondias axillaris</i> Roxb. | Anacardiaceae | Lapsi |
| 61 | <i>Symingtonia populnea</i> (R. Br. Ex Griff.) | Hamamelidaceae | Piple |
| 62 | * <i>Symplocos glomerata</i> King, ex. C.B. Clarke | Symplocaceae | Kholme |
| 63 | * <i>Symplocos theifolia</i> Don. | Symplocaceae | Kharanay |
| 64 | * <i>Tetradium fraxinifolium</i> (Hook.) Hartley | Rutaceae | Khanakpa |
| 65 | <i>Tetrameles nudiflora</i> R.Br. | Tetramelaceae | Mayna |
| 66 | <i>Calicarpa arborea</i> Roxb. | Lamiaceae | Guenlo |
| Shrub and shrublet species | | | |
| 1 | * <i>Antidesma acuminatum</i> Wight | Phyllanthaceae | Lek bilauney |
| 2 | <i>Ardisia macrocarpa</i> Wall. | Myrsinaceae | Damai phal |
| 3 | * <i>Daphne papyraceae</i> Wall. | Thymeleaceae | Kalo Argeli/Kagate |
| 4 | * <i>Dichroa febrifuga</i> Lour | Hydrangeaceae | Basak |
| 5 | * <i>Edgeworthia gardenerii</i> Meissn. | Thymeliaceae | Argali |
| 6 | <i>Eupatorium adenophorum</i> Sprengel | Asteraceae | Kalijhar |
| 7 | <i>Gaultheria fragrantissima</i> Wall. | Ericaceae | Dhasingarey |
| 8 | * <i>Gaultheria nummularioides</i> D.Don | Ericaceae | Kaligedi |
| 9 | <i>Hypericum oblongifolium</i> Choisy | Hypericaceae | Urilo |
| 10 | * <i>Maesa chisia</i> Don | Myrsinaceae | Bilauney |
| 11 | <i>Mahonia napaulensis</i> DC | Berberidaceae | Chutro |
| 12 | <i>Neillia rubiflora</i> D.Don | Rosaceae | Khareto jhar |
| 13 | * <i>Oxyspora paniculata</i> (D.Don) DC | Melastomataceae | Chulesi |
| 14 | * <i>Osbeckia stellata</i> Buch.-Ham.ex Ker Gawl. | Melastomataceae | |
| 15 | <i>Polygala arillata</i> Buch.- Ham ex D.Don. | Polygalaceae | Marcha jhar |
| 16 | <i>Rubus ellipticus</i> Smith. | Rosaceae | Aiselu |

| | | | |
|---------------------|--|-----------------|-----------------------|
| 17 | * <i>Rubus niveus</i> Thunb | Rosaceae | Aiselu / Biralu kanra |
| 18 | <i>Rubus paniculatus</i> (Smith) Rees. | Rosaceae | Kalo Aiselu |
| 19 | * <i>Viburnum erubescens</i> Wallich ex DC | Sambucaceae | Asaray |
| Herb species | | | |
| 1 | * <i>Aconogonum campanulatum</i> (Hook.f.) Hara | Polygonaceae | Kukur thotnay |
| 2 | * <i>Aconogonum molle</i> D. Don | Polygonaceae | Thotnay |
| 3 | * <i>Acorus calamus</i> Linn. | Acoraceae | Bojo |
| 4 | * <i>Aeschynanthus parviflorus</i> (D.Don) Spreng. | Gesneriaceae | Baklay patay |
| 5 | * <i>Aeschynanthus hookeri</i> C.B.Clarke | Gesneriaceae | Baklay patay |
| 6 | * <i>Ampelocissus latifolia</i> (Roxb.) Planch | Vitaceae | Pani lahara |
| 7 | * <i>Anaphalis triplinervis</i> C.B. Clarke | Asteraceae | Bukey Phool |
| 8 | * <i>Arisaema intermedium</i> Blume | Araceae | Larua/Banko |
| 9 | * <i>Arisaema flavum</i> (Forsskal) Schott | Araceae | Sap ko makai |
| 10 | * <i>Arisaema speciosum</i> (Wall.) Mart. | Araceae | Sap ko Makai |
| 11 | * <i>Artemisia vulgaris</i> Linn. | Asteraceae | Titaypati |
| 12 | <i>Astilbe rivularis</i> Ham | Saxifragaceae | Burokhati |
| 13 | * <i>Begonia picta</i> Sm. | Asteraceae | Magar kanje |
| 14 | * <i>Boehmeria platyphylla</i> D.Don | Urticaceae | Kamley |
| 15 | * <i>Campylandra aurantiaca</i> Baker | Asparagaceae | Jangali nakima |
| 16 | * <i>Carex</i> sp. | Cyperaceae | Harkatto |
| 17 | * <i>Cautleya spicata</i> – (J. M. Sm.) Bak | Zingiberaceae | Sara |
| 18 | <i>Centella asiatica</i> (L.) Urban | Umbelliferae | Golpatta |
| 19 | * <i>Commelina benghalensis</i> L. | Commelinaceae | Kanay |
| 20 | * <i>Cyanotis vaga</i> (Loour.) Roem & Schult. | Commelinaceae | Kanay |
| 21 | * <i>Cynodon dactylon</i> Linn | Poaceae | Dubo |
| 22 | * <i>Digitaria sanguinalis</i> (Linn.) Scopoli. | Poaceae | Banso |
| 23 | <i>Drymaria cordata</i> Wild. ex. Roem & Schult. | Caryophyllaceae | Abhijalo |
| 24 | * <i>Elatostema platyphyllum</i> Weddell. | Urticaceae | Gagleto |
| 25 | * <i>Elatostema sessile</i> J.R.Forst. & G.Forst. | Urticaceae | Gagleto |
| 26 | <i>Eragrostis cilianensis</i> (All.) Lut. ex | Poaceae | Banso |
| 27 | * <i>Eupatorium adenophorum</i> Spreng. | Asteraceae | Kali jhar |
| 28 | * <i>Fragaria nubicola</i> Lindley ex. Lacaíta | Rosaceae | Bhui-aiselu |
| 29 | * <i>Gerardiana diversifolia</i> (Link) Friis | Urticaceae | Bhangre sisnu |
| 30 | * <i>Hedychium spicatum</i> Sm. | Zingiberaceae | Gai sara |
| 31 | <i>Hedychium gardnerianum</i> Roscoe | Zingiberaceae | |
| 32 | * <i>Hemiphragma heterophyllum</i> Wall. | Plantaginaceae | Nash jhar |
| 33 | <i>Houttuynia cordata</i> Thunb | Saururaceae | Raktha-jhar |
| 34 | * <i>Impatiens stenantha</i> Hook. f. | Balsaminaceae | Mujuro |
| 35 | * <i>Impatiens urticifolia</i> Wallich | Balsaminaceae | Mujuro |
| 36 | * <i>Lecanthus peduncularis</i> (Wall. ex Royle) Wedd. | Urticaceae | Gagleto |
| 37 | <i>Osbeckia stellata</i> Hook.f | Melastomataceae | Arbal |
| 38 | <i>Oxalis corniculata</i> Linn. | Oxalidaceae | Chariamilo |
| 39 | * <i>Persicaria capitata</i> (Buch.- Ham. ex D.Don) H. Gross | Polygonaceae | Ratnaulo |
| 40 | <i>Pilea stricta</i> (Buchanan-Hamilton ex D. Don) Weddell | Urticaceae | Chiple |
| 41 | <i>Pilea umbrosa</i> Blume. | Urticaceae | Chiple |

| | | | |
|-----------------------------------|---|-----------------|-----------------------------|
| 42 | <i>Pouzolzia sanguine</i> (Blume) Merrill | Urticaceae | Chiple |
| 43 | * <i>Rumex nepalensis</i> Spreng. | Polygonaceae | Halhalley |
| 44 | * <i>Selaginella biformis</i> A. Br. ex Kuhn | Selaginellaceae | Jhew |
| 45 | * <i>Selaginella chrysocaulos</i> (Hook. & Grev.) Spring. | Selaginellaceae | Jhew |
| 46 | * <i>Selaginella monospora</i> Spring. | Selaginellaceae | Jhew |
| 47 | * <i>Smilax</i> sp. | Smilacaceae | Madaney kara / Kirney ghans |
| 48 | * <i>Strobilanthes</i> sp. | Acanthaceae | Kibu ghans |
| 49 | * <i>Swertia bimaculata</i> (Roxb. ex Flem.) Karsten | Gentianaceae | Bhaley chiraito |
| 50 | * <i>Swertia chirayita</i> H. Karsten | Gentianaceae | Chiraito |
| 51 | * <i>Urtica dioica</i> Linn. | Urticaceae | Patley sisnu |
| 52 | <i>Urtica parviflora</i> Roxburgh | Urticaceae | Gharia sisnu |
| 53 | <i>Villebrunea frutescens</i> (Thunb.) Blume | Urticaceae | Chiple |
| 54 | <i>Viola sikkimensis</i> W. Becker | Violaceae | Silamey jhar |
| 55 | * <i>Hedychium</i> sp. | Zingiberaceae | Qiura |
| 56 | <i>Heracleum wallichii</i> DC. | Umbelliferae | Chimphing |
| 57 | * <i>Digitaria ciliaris</i> (Retzius) Koeler | Poaceae | Chitray Banso |
| 58 | * <i>Holboellia angustifolia</i> Diels. | Lardizabalaceae | Gulfa |
| 59 | * <i>Stephania glabra</i> (Roxb.) Miers | Menispermaceae | Tambarkay |
| 60 | <i>Xanthium strumarium</i> L. | Asteraceae | Vede Kuro |
| Epiphyte / Climber species | | | |
| 1 | <i>Aconogonum molle</i> (D. Don) H. Hara | Polygonaceae | Thotne |
| 2 | <i>Arisaema intermedium</i> Blume | Araceae | Larua/Banko |
| 3 | <i>Boehmeria</i> sp. | Urticaceae | Kamley |
| 4 | <i>Cardamine hirsuta</i> L. | Brassicaceae | Titey |
| 5 | <i>Carex</i> sp. | Cyperaceae | Harkatto |
| 6 | <i>Clematis acuminata</i> DC | Ranunculaceae | Pinasay lahara |
| 7 | <i>Clematis b Buchananiana</i> DC. | Ranunculaceae | Pinasey lahara |
| 8 | <i>Codonopsis viridis</i> Wallich. | Campanulaceae | Padey lahara |
| 9 | * <i>Coelogyne flaccida</i> (Lindl.) Kuntz. | Orchidaceae | Sunakhari |
| 10 | <i>Davallodes membranulosa</i> (Hook.) Copel. | Davalliaceae | Uniu |
| 11 | <i>Dendrobium densiflorum</i> | Orchidaceae | Ghogay sunakhari |
| 12 | <i>Digitaria sanguinalis</i> (Linn.) Scopoli. | Poaceae | Banso |
| 13 | <i>Diplazium dilatatum</i> Blume Lek | Woodsiaceae | Chiple Ningro |
| 14 | <i>Diplazium stoliczkae</i> Beddome | Woodsiaceae | Lek kalo ningro |
| 15 | <i>Elatostema platyphyllum</i> Weddell. | Urticaceae | Gagleto |
| 16 | <i>Eragrostis cilianensis</i> (All.) Lut. ex Janchen | Poaceae | Banso |
| 17 | <i>Galium</i> sp. | Rubiaceae | - |
| 18 | <i>Machilus gamblei</i> King ex J. D. Hooker | Lauraceae | Seti kaulo / Ghew kaulo |
| 19 | <i>Mucuna macrocarpa</i> Wall. | Leguminosae | Baldengra |
| 20 | * <i>Pleione praecox</i> (Lindl.) | Orchidaceae | - |
| 21 | * <i>Piper</i> sp. | Piperaceae | |
| 22 | <i>Piper boehmeriaefolia</i> (Miq.) DC. | Piperaceae | Chabo / Jungali pan |
| 23 | * <i>Rhapidiphora decursiva</i> (Roxb.) Schott. | Araceae | Kanchirno |
| 24 | * <i>Rubia cordifolia</i> Linn. | Rubiaceae | Majito |

| | | | |
|--------------------------------------|--|------------------|--------------------|
| 25 | <i>*Schizandra neglecta</i> A.C.Sm. | Schisandraceae | Singatay lahara |
| 26 | <i>Smilax zeylanica</i> Linn. | Liliaceae | Kukur dainey |
| 27 | <i>Smilax aspara</i> L. | Liliaceae | Kukurdaina |
| 28 | <i>Tetrastigma serrulatum</i> (Roxb.) Planchon | Vitaceae | Charcharey lahara |
| 29 | <i>Trichosanthes lepiniana</i> (Naud.) Cogn. | Cucurbitaceae | Indreni |
| 30 | <i>Viscum articulatum</i> Burm. f. | Lorantaceae | Harchur |
| 31 | <i>Wrightia gigantea</i> | Apocynaceae | Bauni Kath |
| Ferns and fern-allies species | | | |
| 1 | <i>*Asplenium laciniatum</i> D. Don. | Aspleniaceae | Uniu |
| 2 | <i>*Blechnum orientale</i> L. | Blechnaceae | Deer Fern |
| 3 | <i>*Coniogramme intermedia</i> Heiron. | Pteridaceae | Uniu |
| 4 | <i>Coniogramme fraxinea</i> (D.Don) Fee ex Diels | Pteridaceae | Bamboo leaf fern |
| 5 | <i>*Cyathea spinulosa</i> Wall.ex Hook | Cyatheaceae | Rukh uniu |
| 6 | <i>*Dennstaedtia appendiculata</i> (Wall.ex Hook.) J.Sm | Dennstaedtiaceae | Piray uniu |
| 7 | <i>*Diplazium dilatatum</i> Blume | Woodsiaceae | Lek Chipley Ningro |
| 8 | <i>*Diplazium esculentum</i> (Retz.) Sw | Woodsiaceae | Chiplay ningro |
| 9 | <i>*Diplazium stoliczkae</i> Beddome | Woodsiaceae | Lek Kalo Ningro |
| 10 | <i>Drynaria</i> sp. | Polypodiaceae | Basket fern |
| 11 | <i>*Equisetum diffusum</i> D.Don. | Equiaetaceae | Salli bisalli |
| 12 | <i>*Gleichenia gigantea</i> Wall. ex Hook | Dryopteridaceae | Kalamey Uniu |
| 13 | <i>Gleichenia longissima</i> Blume | Dryopteridaceae | Sottarey uniu |
| 14 | <i>Lepisorus</i> sp. | Polypodiaceae | Polypods |
| 15 | <i>*Leucostegia truncata</i> (D.Don) Fras.-Jenk. | Davalliaceae | Deer fern |
| 16 | <i>*Lycopodium japonicum</i> Thunb | Lycopodiaceae | Nagbelli |
| 17 | <i>Monachosorum henryi</i> Christ. | Monachosoraceae | Uniu |
| 18 | <i>*Microsorium membranaceum</i> (D.Don) Cing | Polypodiaceae | Uniu |
| 19 | <i>*Nephrolepis cordifolia</i> (Linn.) C. Presl. | Davalliaceae | Pani amala |
| 20 | <i>*Odontosoria chinensis</i> (L.) J.Smith | Lindsaeaceae | Uneu |
| 21 | <i>*Plagiogyria pycnophylla</i> (Kunze.) Mett. | Plagiogyriaceae | Uniu |
| 22 | <i>*Pseudodrynaria coronans</i> (Wall.ex Mett.) T.Moore | Polypodiaceae | Kamray lahara |
| 23 | <i>Pteridium revolutum</i> (Blume) Nakai | Pteridaceae | Uniu |
| 24 | <i>Pteris biaurita</i> L. | Pteridaceae | Uniu |
| 25 | <i>*Pteris wallichiana</i> J. Agardh | Pteridaceae | Uneu |
| 26 | <i>Vittaria elongata</i> Sw | Vittariaceae | Uniu |
| Bamboo / Cane species | | | |
| 1 | <i>Costus speciosus</i> Koenig Sm. | Costaceae | Bethlauri |
| 2 | <i>*Himalayacalamus hookerianus</i> (Munro) Stapleton | Poaceae | Pareng |
| 3 | <i>Phyllostachys aurea</i> Riviere & C.Rivire | Poaceae | Katha Bans |
| 4 | <i>Plectocomia himalayana</i> Giff. | Arecaceae | Fyakray bet |
| 5 | <i>Schizostachyum capitatum</i> (Munro) R.B.Majumdar | Poaceae | Gope Bans |
| 6 | <i>Sinarundinaria intermedia</i> (Munro) C.S.Chao & Renvoize | Poaceae | Nigalo |
| 7 | <i>*Themnocalamus falconeri</i> Hook.f. ex. Munro. | Poaceae | Singanay bans |
| 8 | <i>*Yushania maling</i> (Gamble) R.B.Majumdar & Karthik. | Poaceae | Malingo |
| 9 | <i>*Drapenostachyun intermedium</i> (Munro.) Keng.f. | Poaceae | Titay nigalo |

| Annexure 3: Checklist of floral species recorded along the sampling path of Darap Reserve Forest, West Sikkim | | | | | |
|---|--|---------------|----------------|---------------------------|-------------|
| Sl. No | Botanical Name | Local Name | Family | Altitudinal Range (m) asl | IUCN Status |
| Tree species | | | | | |
| 1 | <i>Albizzia procera</i> Benth. | Seto siris | Fabaceae | | |
| 2 | <i>Alnus nepalensis</i> Don. | Utis | Betulaceae | 200-2800 | LC |
| 3 | <i>Betula cylindrostachya</i> Lindl. ex Wall. | Saur | Betulaceae | 1400-2800 | LC |
| 4 | <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. | Patley katush | Fagaceae | 1600-1600 | NA |
| 5 | <i>Castanopsis tribuloides</i> (Smith) A. DC | Musre katush | Fagaceae | 450-2300 | NA |
| 6 | <i>Castanopsis indica</i> (Roxb. ex Lindl.) A.DC. | Dalney katus | Fagaceae | 1500-1500 | NA |
| 7 | <i>Choerospondias axillaris</i> (Roxb.) B.L.Burt&A.W.Hill | Lapsi | Anacardiaceae | 900-2500 | NA |
| 8 | <i>Cryptomeria japonica</i> (Thunberg ex. Linn. F.) D. Don | Dhupi | Taxodiaceae | 1100-2500 | NT |
| 9 | <i>Duabanga grandiflora</i> (DC.) Walp. | Lampate | Lythraceae | 900-1500 | NA |
| 10 | <i>Engelhardtia spicata</i> Lechen ex Blume. | Mauwa | Juglandaceae | 500-2100 | LC |
| 11 | <i>Erythrina arborescens</i> Roxb. | Phalado | Fabaceae | 400-2100 | NA |
| 12 | <i>Eurya acuminata</i> DC. | Jhingni | Theaceae | 700-3000 | NA |
| 13 | <i>Exbucklandia populnea</i> (R. Br. Ex Griff) R. W. Br | Piplee | Hamamelidaceae | 1200-2000 | NA |
| 14 | <i>Ficus nemarolis</i> Wall. | Dudhilo | Moraceae | 2000 | NA |
| 15 | <i>Hovenia dulcis</i> Thunb. | Bangi | Thymelaeaceae | 1900 | NA |
| 16 | <i>Jambosa formosa</i> (Wall.) G. Don. | Ambakey | Myrtaceae | 1800 | |
| 17 | <i>Juglans regia</i> L. | Okhar | Juglandaceae | 500-1800 | LC |
| 18 | <i>Leucosceptrum canum</i> Sm. | Gurpis | Lamiaceae | 1900 | NA |
| 19 | <i>Lithocarpus fenestratus</i> (Roxb.) Rehde | Arkowlo | Fagaceae | 1800 | NA |
| 20 | <i>Lyonia ovalifolia</i> var. <i>ovalifolia</i> | Angeri | Ericaceae | 200-3400 | NA |
| 21 | <i>Macaranga denticulata</i> (Blume) Müll.Arg. | Malata | Euphorbiaceae | 100-1300 | NA |
| 22 | <i>Machilus</i> sp. | Kawlo | Lauraceae | 1700-2000 | NA |
| 23 | <i>Maesa</i> sp. | Bilauney | Myrtaceae | 1900 | NA |
| 24 | <i>Magnolia velutina</i> DC. | Phusre champ | Magnoliaceae | 2000 | NA |
| 25 | <i>Magnolia doltsopa</i> (Buch.-Ham. ex DC.) Figlar | Ranichamp | Magnoliaceae | 1500-2400 | NA |
| 26 | <i>Magnolia cathcartii</i> (Hook. f. & Thomson) Noot. | Titey champ | Magnoliaceae | 1400-2700 | LC |
| 27 | <i>Ostodes paniculata</i> Blume | Bepari | Euphorbiaceae | 1500 | NA |
| 28 | <i>Persea odoratissima</i> (Nees) Kosterm. | Kawlo | Lauraceae | 1500-2100 | NA |
| 29 | <i>Prunus bracteopadus</i> Koehne | Arupatey | Rosaceae | 1700-2000 | NA |
| 30 | <i>Rhus chinensis</i> Mill. | Bhakimlo | Anacardiaceae | 1600 | NA |
| 31 | <i>Rhus succedanea</i> Linn. | Rani bhalayo | Anacardiaceae | 1800 | NA |
| 32 | <i>Schima wallichii</i> Choisy | Chilaune | Theaceae | 800-1800 | NA |
| 33 | <i>Symplocos glomerata</i> King ex C.B. Clarke | Kholme | Symplocaceae | 1200-2700 | NA |
| 34 | <i>Symplocos lucida</i> (Thunb.) Siebold & Zucc | Kharane | Symplocaceae | 1500-3000 | NA |
| 35 | <i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg | Panisaj | Combretaceae | 900 | NA |
| 36 | <i>Tetradium fraxinifolium</i> (Hook. f.) T.G. | Khanakpa | Rutaceae | 1900 | NA |

| | | | | | |
|-----------------------------------|---|--------------|-----------------|-----------|----|
| | Hartley | | | | |
| 37 | <i>Zanthoxylum acanthopodium</i> DC | Boke timmur | Rutaceae | | |
| Shrub and shrublet species | | | | | |
| 1 | <i>Ardisia macrocarpa</i> Wall. | Damai phal | Myrsinaceae | 1500-2400 | NA |
| 2 | <i>Brassaiopsis mitis</i> Clarke | Chuletro | Araliaceae | | |
| 3 | <i>Dichroa febrifuga</i> Lour. | Basak | Hydrangaceae | 200-2000 | NA |
| 4 | <i>Mahonia napaulensis</i> DC. | Kesar | Berberidaceae | | |
| 5 | <i>Mussaenda roxburghii</i> Hook. f. | Dhobini phul | Rubiaceae | | |
| 6 | <i>Neillia rubiflora</i> D. Don | Kirkeray | Rosaceae | | |
| 7 | <i>Osbeckia stellata</i> Buch.-Ham.ex D. Don | LoteJhar | Melastomataceae | 200-2300 | NA |
| 8 | <i>Osbeckia nepalensis</i> Hook. F | LoteJhar | Melastomataceae | | |
| 9 | <i>Oxyspora paniculata</i> (D.Don) DC | Chulesee | Melastomataceae | | |
| 10 | <i>Pilea</i> sp. | Chipleay | Urticaceae | | |
| 11 | <i>Polygonum</i> sp. | Rani thotney | Polygonaceae | | |
| 12 | <i>Rubus ellipticus</i> Sm. | Aiselu | Rosaceae | 1000-2600 | NA |
| 13 | <i>Rubus paniculatus</i> Sm. | Aiselu | Rosaceae | | |
| 14 | <i>Strobilanthes</i> sp. | kebu | Acanthaceae | 2700-3600 | NA |
| 15 | <i>Viburnum erubescens</i> Wall. ex D | Asarey | Adoxaceae | 1400-3950 | NA |
| Herb species | | | | | |
| 1 | <i>Arisaema intermedium</i> Blume | Larua/Banko | Araceae | 2600-3400 | NA |
| 2 | <i>Artemisia vulgaris</i> L. | Titey pate | Compositae | 1500-3800 | NA |
| 3 | <i>Astilbe rivularis</i> Buch.-Ham. ex D. Don | Budi okhati | Saxifragaceae | 900-3200 | NA |
| 4 | <i>Begonia rubella</i> Buch.-Ham. ex D. Don | Magarkachi | Begoniaceae | 1000-1900 | NA |
| 5 | <i>Begonia</i> sp. | Magarkachi | Begoniaceae | | |
| 6 | <i>Bidens pilosa</i> Linn. | Kuro | Asteraceae | 200-1900 | NA |
| 7 | <i>Carex</i> sp. | Harkatto | Cyperaceae | 1500-2000 | |
| 8 | <i>Carex baccans</i> Nees | Harkatto | Cyperaceae | 200-2700 | LC |
| 9 | <i>Commelina benghalensis</i> Linn. | Kaneyjhar | Commelinaceae | | |
| 10 | <i>Crotalaria</i> sp. | | Leguminosae | | |
| 11 | <i>Cyperus eragrostis</i> Lam | Harkatto | Cyperaceae | 200-1000 | LC |
| 12 | <i>Cyperus scariosus</i> R.Br. | Harkatto | Cyperaceae | 200-1500 | NA |
| 13 | <i>Desmodium</i> sp. | | Leguminosae | | |
| 14 | <i>Digitaria</i> sp. | Banso | Poaceae | | |
| 15 | <i>Elatostema platyphyllum</i> Weddell. | Gagleto | Urticaceae | 200-1500 | NA |
| 16 | <i>Elatostema sessile</i> J.R.Forst. & G.Forst. | Galato | Urticaceae | 1000-1700 | NA |
| 17 | <i>Eragrostis</i> sp. | | Poaceae | 1500-2500 | |
| 18 | <i>Eupatorium adenophorum</i> Spreng. | Kalijhar | Asteraceae | | |
| 19 | <i>Fragaria nubicola</i> Lindley ex Lacaita | VuiAiselu | Rosaceae | 2500-3900 | NA |
| 20 | <i>Gerardiana diversifolia</i> (Link) Friis | Bhangresisnu | Urticaceae | 300-2800 | NA |
| 21 | <i>Globba sessiliflora</i> Sims | Sara | Zingiberaceae | 1700-2300 | LC |
| 22 | <i>Hedychium spicatum</i> Smith | Sara | Zingiberaceae | 1800-2800 | NA |
| 23 | <i>Heracleum wallichii</i> DC | Chimphing | Apiaceae | 1900-2700 | NA |
| 24 | <i>Hemiphragma heterophyllum</i> Wall. | | Plantaginaceae | 2600-4100 | NA |
| 25 | <i>Impatiens arguta</i> Hook.f. & Thomson | Mujuro | Balsaminaceae | 1800-3200 | NA |
| 26 | <i>Impatiens dolichoceras</i> Pritz. ex Diels | Mujuro | Balsaminaceae | 1800-3200 | NA |
| 27 | <i>Impatiens latiflora</i> Hook.f. & Thomson | Mujuro | Balsaminaceae | 1200-2100 | NA |
| 28 | <i>Impatiens</i> sp. | | Balsaminaceae | | |
| 29 | <i>Impatiens stenantha</i> Hook.f. | Mujuro | Balsaminaceae | | |

| | | | | | |
|-------------------------------------|--|-------------------|-----------------|-----------|----|
| 30 | <i>Laportea terminalis</i> Wight. | Patlesisnu | Urticaceae | 1600-2600 | NA |
| 31 | <i>Nepeta</i> sp. | | Lamiaceae | | |
| 32 | <i>Oxalis corniculata</i> Linn | Amilojhar | Oxalidaceae | 1400-1900 | NA |
| 33 | <i>Persicaria capitata</i> (Buch.Ham.exD.Don) Gross | Ratneulo | Polygonaceae | 1500-2300 | |
| 34 | <i>Persicaria nepalensis</i> (Meisn.) Miyabe | Ratneulo | Polygonaceae | | |
| 35 | <i>Pilea umbrosa</i> Wall. ex Blume | Chipleghans | Urticaceae | 1200-2500 | NA |
| 36 | <i>Polygonum molle</i> D. Don | Thotney | Polygonaceae | 1200-3400 | NA |
| 37 | <i>Potentilla penduncularis</i> D. Don | | Rosaceae | 3000-4800 | NA |
| 38 | <i>Rohdea nepalensis</i> (Raf.) N.Tanaka | JangleeNakima | Asparagaceae | | |
| 39 | <i>Rubus calycinus</i> Wall. ex D. Don | | Rosaceae | 1200-3000 | NA |
| 40 | <i>Rumex nepalensis</i> Sprengel | Halhalley | Polygonaceae | 1000-4300 | NA |
| 41 | <i>Selinum</i> sp. | | Apiaceae | | |
| 42 | <i>Swertia bimaculata</i> (Siebold & Zucc.) Hook. f. & Thomson ex C.B. Clarke | Chirito | Gentianaceae | 200-3000 | NA |
| Climber and epiphyte species | | | | | |
| 1 | <i>Clematis buchananiana</i> DC. | Pinasey lahara | Ranunculaceae | 1200-2800 | NA |
| 2 | <i>Herpetospermum pedunculatum</i> (Seringe.) C.B. Clarke | Ban karela | Cucurbitaceae | 2300-2500 | NA |
| 3 | <i>Holboellia angustifolia</i> Wall. | Gulfa | Lardizabalaceae | 1000-2700 | NA |
| 4 | <i>Piper boechmeriaefolium</i> (Miq.) DC. | Chambo | Piperaceae | 1000-2400 | NA |
| 5 | <i>Rhaphidophora decursiva</i> (Roxb.) Scott | Kanchirna | Araceae | 2000 | NA |
| 6 | <i>Rhaphidophora</i> sp. | Kanchirna | Araceae | | |
| 7 | <i>Rubia cordifolia</i> L | Manjith | Rubiaceae | 300-2800 | NA |
| 8 | <i>Smilax zeylanica</i> Linn. | Kukurdainey | Liliaceae | 600-1700 | NA |
| 9 | <i>Stephania</i> sp. | Tamarkey | Menispermaceae | 1500-2300 | NA |
| 10 | <i>Tetrastigma serrulatum</i> (Roxb.) Planch | Charcharay lahara | Vitaceae | 1800-2500 | NA |
| 11. | <i>Trichosanthes lepiniana</i> (Naudin) Cogn. | Inderani | Cucurbitaceae | 700-2000 | NA |
| Fern and fern-allies species | | | | | |
| 1 | <i>Asplenium lacinatedum</i> D.Don | | Aspleniaceae | 1000-2500 | NA |
| 2 | <i>Cyathea</i> sp. | | Cyatheaceae | | |
| 3 | <i>Dicranopteris</i> sp. | Sottar | Gleicheniaceae | | NA |
| 4 | <i>Diplazium</i> sp. | Sauneyningro | Athyriaceae | 1700-2500 | NA |
| 5 | <i>Diplopterygium gigantean</i> Wall. ex Hook | | Gleicheniaceae | 800-2800 | NA |
| 6 | <i>Huperzia</i> sp. | | Lycopodiaceae | | |
| 7 | <i>Lycopodium japonicum</i> Thunb. | Nagbelli | Lycopodiaceae | 100-3300 | NA |
| 8 | <i>Plagiogyria pycnophylla</i> (Kunze) Mett | | Plagiogyriaceae | | |
| 9 | <i>Selaginella</i> sp. | | Selaginellaceae | 2500 | NA |
| Orchid species | | | | | |
| 1 | <i>Agrostophyllum callosum</i> Rchb.f | | Orchidaceae | | |
| 2 | <i>Bulbophyllum</i> sp. | | Orchidaceae | | |
| 3 | <i>Coelogyne fuscescens</i> Lindl. | | Orchidaceae | | |
| 4 | <i>Coelogyne</i> sp. | | Orchidaceae | | |
| 5 | <i>Cymbidium cochleare</i> Lindl. | | Orchidaceae | | |
| 6 | <i>Gastrochilus acutifolius</i> (Lindl.) Kunze | | Orchidaceae | | |

| | | | | | |
|----|---|--|-------------|--|--|
| 7 | <i>Gastrochilus inconspicuus</i> (Hook.f.) Kuntze | | Orchidaceae | | |
| 8 | <i>Pleione humilis</i> (Sm.) D. Don | | Orchidaceae | | |
| 9 | <i>Pleione praecox</i> (Smith) D. Don | | Orchidaceae | | |
| 10 | <i>Vanda</i> sp. | | Orchidaceae | | |
| 11 | <i>Otochilus fuscus</i> Lindl. | | Orchidaceae | | |
| 12 | <i>Liparis</i> sp. | | Orchidaceae | | |

| Annexure 4: Checklist of floral species recorded along Maniping Reserve Forest sampling path | | | |
|--|---|---------------|-----------------|
| S. No | Scientific Name | Local Name | Family |
| Tree species | | | |
| 1 | <i>Acer campbellii</i> Hook.f. & Thomson ex Hiern | Kapasey | Aceraceae |
| 2 | <i>Acer caudatum</i> Wallich. | Kapasey | Aceraceae |
| 3 | <i>Alnus nepalensis</i> D.Don | Utis | Betulaceae |
| 4 | <i>Andromeda elliptica</i> Siebold & Zucc. | | Ericaceae |
| 5 | <i>Cryptomeria japonica</i> (Thunb. ex L.f.) D.Don | Dhuppi | Taxodiaceae |
| 6 | <i>Eurya acuminata</i> DC. | Sanujhingni | Theaceae |
| 7 | <i>Leucosceptrum canum</i> Sm. | Ghurpis | Magnoliaceae |
| 8 | <i>Lithocarpus pachyphyllus</i> (Kurz) Rehder | Bantey | Fagaceae |
| 9 | <i>Lyonia ovalifolia</i> (Wall.) Drude | Angeri | Rosaceae |
| 10 | <i>Michelia doltsopa</i> Buch.-Ham. ex Dc. | Rani chanp | Magnoliaceae |
| 11 | <i>Machilus edulis</i> King ex Hook. f. | Pomsi | Lauraceae |
| 12 | <i>Magnolia campbellii</i> Hook.f. & Thom. | Ghogeyp champ | Magnoliaceae |
| 13 | <i>Myrica esculenta</i> Buch.-Ham. ex D. Don | Kafal | Tamaricaceae |
| 14 | <i>Quercus lamellosa</i> Sm. | Bajranth/Buk | Fagaceae |
| 15 | <i>Rapanea capitellata</i> (Wall.)Mez | | Primulaceae |
| 16 | <i>Rhododendron arboreum</i> Sm. | LaliGurans | Ericaceae |
| 17 | <i>Rhododendron falconeri</i> Hook.f. | Korlinga | Ericaceae |
| 18 | <i>Rhododendron hodgsonii</i> Hook. f. | Korlinga | Ericaceae |
| 19 | <i>Symplocos glomerata</i> King ex C.B. Clarke | Kholme | Symplocaceae |
| 20 | <i>Symplocos lucida</i> (Thunb.) Siebold & Zucc. | Kharaney | Symplocaceae |
| 21 | <i>Zanthoxylum acanthopodium</i> DC. | Boke timmur | Rutaceae |
| Shrub species | | | |
| 1 | <i>Viburnum erubescens</i> Wallich ex DC | Asare | Caprifoliaceae |
| 2 | <i>Rubus ellipticus</i> Smith | Ainselu | Rosaceae |
| 3 | <i>Osbeckia stellata</i> Buch.-Ham. ex D. Don | Chulesi | Melastomataceae |
| 4 | <i>Rosa sericea</i> Lindl. | Bhotegulab | Rosaceae |
| 5 | <i>Ilex sikkimensis</i> Kurz. | Lise | Aquifoliaceae |
| 6 | <i>Berberis angulossa</i> Wallich ex Hook f. & Thoms. | Chutre kada | Berberidaceae |
| 7 | <i>Mahonia sikkimensis</i> Takeda | Chutro | Berberidaceae |
| 8 | <i>Daphne cannabina</i> Wall. | Kalo argeli | Thymelaeaceae |
| Herb species | | | |
| 1 | <i>Anaphalis margaritacea</i> Linn. | Bukiful | Asteraceae |
| 2 | <i>Aconogonum molle</i> D. Don | Thotne | Polygonaceae |
| 3 | <i>Arisaema</i> sp. | Larua/Banko | Araceae |
| 4 | <i>Artimesia wallichiana</i> Besser | Titeypati | Asteraceae |
| 5 | <i>Bidens pilosa</i> Linn. | Kuro | Asteraceae |
| 6 | <i>Carex</i> sp. | Harkatto | Cariceae |
| 7 | <i>Cynodondactylon</i> Linn. | Dubo | Poaceae |
| 8 | <i>Eupatorium adenophorum</i> (Spreng.) King & H. Rob | Kali jhar | Asteraceae |

| | | | |
|--|---|-------------------|------------------|
| 9 | <i>Fragaria nubicola</i> Lindley ex. Lacaíta | Vui aiselu | Rosaceae |
| 10 | <i>Gerardiana diversifolia</i> (Link) Friis | Bhangre sisnu | Urticaceae |
| 11 | <i>Hemiphragma heterophyllum</i> Wall. | Lalgeri | Scrophulariaceae |
| 12 | <i>Heracleum wallichii</i> DC | Chimping | Apiaceae |
| 13 | <i>Impatiens urticifolia</i> Wallich | | Balsaminaceae |
| 14 | <i>Oxalis corniculata</i> Linn. | Amilo jhar | Oxalidaceae |
| 15 | <i>Persicaria capitata</i> (D. Don) H. Gross | Ratnaulo | Polygonaceae |
| 16 | <i>Pilea scripta</i> (Buch. - Ham. ex D. Don) Wedd. | Chipleghans | Ulmaceae |
| 17 | <i>Pilea umbrosa</i> Blume. | Chiple | Urticaceae |
| 18 | <i>Rumex nepalensis</i> Spreng. | Halhalley | Polygonaceae |
| 19 | <i>Solanum khasianum</i> CB Clarke | Boksi kara | Solanaceae |
| 20 | <i>Swertia bimaculata</i> Hooker & Thomson ex C.B. Clarke | Bhaley chirowto | Gentianaceae |
| 21 | <i>Urtica dioica</i> Linn. | Patley sisnu | Urticaceae |
| 22 | <i>Viola bicolor</i> Pursh. | | Violaceae |
| Climber and epiphyte species | | | |
| 1 | <i>Cissus elongata</i> Roxburgh. | Charcharey lahara | Vitaceae |
| 2 | <i>Clematis b Buchananiana</i> DC | Pinasey lahara | Rununculaceae |
| 3 | <i>Crawfordia speciosa</i> C.B. Clarke | Blue bell flower | Gentianaceae |
| 4 | <i>Dendrobium chrysanthum</i> Wall. ex Lindl. | | Orchidaceae |
| 5 | <i>Piper boehmeriifolium</i> (Miquel.) Wall. ex C. DC | Jungle paan | Piperaceae |
| 6 | <i>Pleione praecox</i> (Sm.) D. Don | | Orchidaceae |
| 7 | <i>Rhaphidophora decursiva</i> (Roxb.) Schott | Kanchirna | Araceae |
| 8 | <i>Rubia manjith</i> Roxb. ex Fleming | Majito | Rubiaceae |
| 9 | <i>Trichosanthes lepiniana</i> (Naudin) Cogn. | Indreni | Cucurbitaceae |
| 10 | <i>Usnea</i> sp. | | Parmeliaceae |
| Ferns & fern-allies species | | | |
| 1 | <i>Asplenium ensiforme</i> Wall. ex Hook. & Grev. | Uniu | Aspleniaceae |
| 2 | <i>Diplazium dilatatum</i> Blume | Lek chipleghingro | Woodsiaceae |
| 3 | <i>Dryopteris redactopinnata</i> Basu and Panigrahi | Uniu | Dryopteridaceae |
| 4 | <i>Lycopodium clavatum</i> Linn. | Nagbeli | Lycopodiaceae |
| 5 | <i>Nephrolepis cordifolia</i> (L.) C. Presl | Pani amala | Davalliaceae |
| 6 | <i>Pteridium revolutum</i> (Blume) Nakai | | Dennstaedtiaceae |
| 7 | <i>Pteris wallichiana</i> J. Agardh | Chatey uniu | Pteridaceae |
| 8 | <i>Pteris wallichiana</i> J. Agardh | Chatey uniu | Pteridaceae |
| 9 | <i>Selaginella monospora</i> Spring. | | Selaginellaceae |
| 10 | <i>Sphagnum squarrosum</i> Crome | Jhyaw | Sphagnaceae |
| Bamboo species | | | |
| 1 | <i>Arundinaria maling</i> Gamble | Malingo | Poaceae |

| Annexure 5: Checklist of floral species recorded along the sampling path of Nambu Reserve Forest in West Sikkim | | | | | |
|---|---|---------------|----------------|----------------------------|-------------|
| Sl. No | Botanical Name | Local Name | Family | Altitudinal Ranges (m) asl | IUCN Status |
| Tree species | | | | | |
| 1 | <i>Acer campbellii</i> Hook.f. & Thomson ex Hiern | Kapasey | Sapindaceae | 1800-2700 | LC |
| 2 | <i>Actinodaphne sikkimensis</i> Meisn | Sisi | Lauraceae | 1700-1700 | NA |
| 3 | <i>Albizzia procera</i> Benth. | Seto siris | Fabaceae | | |
| 4 | <i>Alnus nepalensis</i> Don. | Utis | Betulaceae | 200-2800 | LC |
| 5 | <i>Beilschmiedia sikkimensis</i> King ex Hook. f. | Tarsing | Lauraceae | 300-2400 | NA |
| 6 | <i>Brassaiopsis mitis</i> C.B.Clarke | | Araliaceae | | |
| 7 | <i>Betula cylindrostachya</i> Lindl. ex Wall. | Saur | Betulaceae | 1400-2800 | LC |
| 8 | <i>Castanopsis hystrix</i> Hook. & Thomson ex. A. DC. | Patley katush | Fagaceae | 1600-1600 | NA |
| 9 | <i>Castanopsis tribuloides</i> (Smith) A. DC | Musre katush | Fagaceae | 450-2300 | NA |
| 10 | <i>Castanopsis indica</i> (Roxb. ex Lindl.) A.DC. | Dalney katus | Fagaceae | 1500-1500 | NA |
| 11 | <i>Choerospondias axillaris</i> (Roxb.) B.L.Burt & A.W.Hill | Lapsi | Anacardiaceae | 900-2500 | NA |
| 12 | <i>Cryptomeria japonica</i> (Thunberg ex. Linn. F.) D. Don | Dhupi | Taxodiaceae | 1100-2500 | NT |
| 13 | <i>Duabanga grandiflora</i> (DC.) Walp. | Lampate | Lythraceae | | |
| 14 | <i>Elaeocarpus lanceifolius</i> Roxb. | Bhadrasay | Elaeocarpaceae | 1800-2500 | NA |
| 15 | <i>Engelhardtia spicata</i> Lechen ex Blume. | Mauwa | Juglandaceae | 500-2100 | LC |
| 16 | <i>Erythrina arborescens</i> Roxb. | Phalado | Fabaceae | 400-2100 | NA |
| 17 | <i>Eurya acuminata</i> DC. | Jhingni | Theaceae | 700-3000 | NA |
| 18 | <i>Exbucklandia populnea</i> (R. Br. Ex Griff) R. W. Br | Piplee | Hamamelidaceae | 1200-2000 | NA |
| 19 | <i>Ficus nemarolis</i> Wall. | Dudhilo | Moraceae | | |
| 20 | <i>Hovenia dulcis</i> Thunb. | Bangi | Thymelaeaceae | | |
| 21 | <i>Jambosa formosa</i> (Wall.) G. Don. | Ambakey | Myrtaceae | | |
| 22 | <i>Juglans regia</i> L. | Okhar | Juglandaceae | 500-1800 | LC |
| 23 | <i>Lithocarpus fenestratus</i> (Roxb.) Rehde | Arkowlo | Fagaceae | | |
| 24 | <i>Lithocarpus pachyphyllus</i> (Kurz) Rehder | Katus | Fagaceae | | |
| 25 | <i>Lyonia ovalifolia</i> var. <i>ovalifolia</i> | Angeri | Ericaceae | 200-3400 | NA |
| 26 | <i>Macaranga denticulata</i> (Blume) Müll.Arg. | Malata | Euphorbiaceae | 100-1300 | NA |
| 27 | <i>Machilus</i> sp. | Kawlo | Lauraceae | 1700-2000 | |

| | | | | | |
|----------------------|---|---------------|-----------------|-----------|----|
| 28 | <i>Maesa</i> sp. | Bilauney | Myrtaceae | | |
| 29 | <i>Magnolia cathcartii</i> (Hook. f. & Thomson) Noot. | Titey champ | Magnoliaceae | 1400-2700 | LC |
| 30 | <i>Magnolia velutina</i> DC. | Phusrey champ | Magnoliaceae | | |
| 31 | <i>Magnolia doltsopa</i> (Buch.-Ham. ex DC.) Figlar | Rani champ | Magnoliaceae | 1500-2400 | |
| 32 | <i>Meliosma arnottiana</i> (Wight) Walp. | Dabdabey | Sabiaceae | | |
| 33 | <i>Myrsine semiserrata</i> Wall | Phalame | Primulaceae | 500-2700 | NA |
| 34 | <i>Persea odoratissima</i> (Nees) Kosterm. | Kawlo | Lauraceae | 1500-2100 | NA |
| 35 | <i>Prunus bracteopadus</i> Koehne | Arupatey | Rosaceae | 1700-2000 | NA |
| 36 | <i>Pyrularia edulis</i> (Wall.) A. DC. | Amphi | Santalaceae | 1700-1700 | NA |
| 37 | <i>Quercus lamellosa</i> Sm. | Buk | Fagaceae | 1600-2800 | NA |
| 38 | <i>Rhododendron arboreum</i> Sm. | Guras | Ericaceae | 1800-3000 | NA |
| 39 | <i>Rhus chinensis</i> Mill. | Bhakimlo | Anacardiaceae | | NA |
| 40 | <i>Rhus succedanea</i> Linn. | Rani bhalayo | Anacardiaceae | | NA |
| 41 | <i>Schima wallichii</i> Choisy | Chilaune | Theaceae | 800-1800 | NA |
| 42 | <i>Symplocos glomerata</i> King ex C.B. Clarke | Kholme | Symplocaceae | 1200-2700 | NA |
| 43 | <i>Symplocos lucida</i> (Thunb.) Siebold & Zucc | Kharane | Symplocaceae | 1500-3000 | NA |
| 44 | <i>Tetradium fraxinifolium</i> (Hook. f.) T.G. Hartley | Khanakpa | Rutaceae | 1200-2500 | NA |
| Shrub species | | | | | |
| 1 | <i>Ardisia macrocarpa</i> Wall. | Damai phal | Myrsinaceae | 1500-2400 | NA |
| 2 | <i>Daphne cannabina</i> Wall | Kalo argeli | Thymeleaceae | 1900-2700 | NA |
| 3 | <i>Dichroa febrifuga</i> Lour. | Basak | Hydrangaceae | 200-2000 | NA |
| 4 | <i>Dobinea vulgaris</i> Buch.-Ham. ex D. Don | | Anacardiaceae | | |
| 5 | <i>Osbeckia stellata</i> Buch.-Ham. ex D. Don | Chulesi | Melastomataceae | 200-2300 | NA |
| 6 | <i>Oxyspora paniculata</i> (D. Don) DC | Chulesi | Melastomataceae | 500-2000 | NA |
| 7 | <i>Rubus ellipticus</i> Sm. | Aiselu | Rosaceae | 1000-2600 | NA |
| 8 | <i>Strobilanthus wallichii</i> Nees. | Kibu | Thymeleaceae | 2700-3600 | NA |
| 9 | <i>Viburnum cylindricum</i> Buch.-Ham. ex D. Don | | Adoxaceae | | |
| 10 | <i>Viburnum erubescens</i> Wall. ex D | Asarey | Adoxaceae | 1400-3950 | NA |
| Herb species | | | | | |
| 1 | <i>Anaphalis triplinervis</i> (Sims) Sims ex C. B. Clarke | | Compositae | | |
| 2 | <i>Arisaema intermedium</i> Blume | Larua/Banko | Araceae | 2600-3400 | NA |
| 3 | <i>Artemisia vulgaris</i> L. | Titey pate | Compositae | 1500-3800 | NA |
| 4 | <i>Astilbe rivularis</i> Buch.-Ham. ex | Budi okhati | Saxifragaceae | 900-3200 | NA |

| | | | | | |
|----|---|---------------|----------------|-----------|----|
| | D. Don | | | | |
| 5 | <i>Begonia rubella</i> Buch.-Ham. ex D. Don | Magarkachi | Begoniaceae | 1000-1900 | NA |
| 6 | <i>Begonia</i> sp. | Magarkachi | Begoniaceae | | |
| 7 | <i>Bidens pilosa</i> Linn. | Kuro | Asteraceae | 200-1900 | NA |
| 8 | <i>Carex</i> sp. | Harkatto | Cyperaceae | 1500-2000 | |
| 9 | <i>Carex baccans</i> Nees | Harkatto | Cyperaceae | 200-2700 | LC |
| 10 | <i>Codonopsis gracilis</i> Hook.f. & Thomson | | Campanulaceae | | |
| 11 | <i>Commelina benghalensis</i> Linn. | Kaneyjhar | Commelinaceae | 2300-2300 | |
| 12 | <i>Craniotome furcata</i> (Link) Kuntze | | Lamiaceae | 900-3200 | NA |
| 13 | <i>Cyathula capitata</i> Moq. | | Amaranthaceae | 1700-2300 | NA |
| 14 | <i>Cyperus eragrostis</i> Lam | Harkatto | Cyperaceae | 200-1000 | LC |
| 15 | <i>Cyperus scariosus</i> R.Br. | Harkatto | Cyperaceae | 200-1500 | NA |
| 16 | <i>Digitaria</i> sp. | Banso | Poaceae | | |
| 17 | <i>Elatostema platyphyllum</i> Weddell. | Gagleto | Urticaceae | 700-1900 | NA |
| 18 | <i>Elatostema sessile</i> J.R.Forst. & G.Forst. | Galato | Urticaceae | 1000-1700 | NA |
| 19 | <i>Eragrostis</i> sp. | | Poaceae | 1500-2500 | |
| 20 | <i>Eupatorium adenophorum</i> Spreng. | Kali jhar | Asteraceae | | |
| 21 | <i>Fragaria nubicola</i> Lindley ex Lacaita | Vui aiselu | Rosaceae | 2500-3900 | NA |
| 22 | <i>Gerardiana diversifolia</i> (Link) Friis | Bhangre sisnu | Urticaceae | 300-2800 | NA |
| 23 | <i>Globba sessiliflora</i> Sims | Sara | Zingiberaceae | 1700-2300 | LC |
| 24 | <i>Hedychium spicatum</i> Smith | Sara | Zingiberaceae | 1800-2800 | NA |
| 25 | <i>Hemiphragma heterophyllum</i> Wall. | | Plantaginaceae | 2600-4100 | NA |
| 26 | <i>Heracleum wallichii</i> DC | Chimphing | Apiaceae | 1900-2700 | NA |
| 27 | <i>Himalaiella deltoidea</i> (DC.) Raab-Straube | | Compositae | | |
| 28 | <i>Impatiens arguta</i> Hook.f. & Thomson | Mujuro | Balsaminaceae | 1800-3200 | NA |
| 29 | <i>Impatiens dolichoceras</i> Pritz. ex Diels | Mujuro | Balsaminaceae | 1200-2100 | NA |
| 30 | <i>Impatiens latiflora</i> Hook.f. & Thomson | Mujuro | Balsaminaceae | 1200-2100 | NA |
| 31 | <i>Impatiens</i> sp. | | Balsaminaceae | | |
| 32 | <i>Impatiens stenantha</i> Hook.f. | Mujuro | Balsaminaceae | 2400-3000 | NA |
| 33 | <i>Isodon</i> sp. | | Lamiaceae | | |
| 34 | <i>Laportea terminalis</i> Wight. | Patle sisnu | Urticaceae | 1600-2600 | NA |
| 35 | <i>Lysionotus serratus</i> D. Don | | Gesneriaceae | 300-2800 | NA |
| 36 | <i>Myriactis nepalensis</i> Less. | | Compositae | 700-3700 | NA |
| 37 | <i>Nepeta</i> sp. | | Lamiaceae | | |
| 38 | <i>Ophiorrhiza mungos</i> L. | | Rubiaceae | | NA |

| | | | | | |
|-------------------------------------|---|------------------|----------------|-----------|----|
| 39 | <i>Oxalis corniculata</i> Linn | Amilo jhar | Oxalidaceae | 1400-1900 | NA |
| 40 | <i>Persicaria capitata</i> (Buch.Ham.ex D.Don) Gross | Ratneulo | Polygonaceae | 1500-2300 | NA |
| 41 | <i>Persicaria chinensis</i> (L.) H. Gross | | Polygonaceae | 2800 | NA |
| 42 | <i>Persicaria nepalensis</i> (Meisn.) Miyabe | Ratneulo | Polygonaceae | 1200-3500 | NA |
| 43 | <i>Pilea umbrosa</i> Wall. ex Blume | Chiplej ghans | Urticaceae | 1200-2500 | NA |
| 44 | <i>Polygonatum</i> sp. | | Asparagaceae | 2500 | |
| 45 | <i>Polygonum molle</i> D. Don | Thotney | Polygonaceae | 1200-3400 | NA |
| 46 | <i>Rohdea nepalensis</i> (Raf.) N.Tanaka | JangleeNakima | Asparagaceae | 1500-2000 | NA |
| 47 | <i>Rubus calycinus</i> Wall. ex D. Don | | Rosaceae | 1200-3000 | NA |
| 48 | <i>Rubus niveus</i> Thunb. | | Rosaceae | 500-2800 | NA |
| 49 | <i>Rumex nepalensis</i> Sprengel | Halhalley | Polygonaceae | 1000-4300 | NA |
| 50 | <i>Selinum</i> sp. | | Apiaceae | | |
| 51 | <i>Swertia bimaculata</i> (Siebold & Zucc.) Hook. f. & Thomson ex C.B. Clarke | Chirito | Gentianaceae | 200-3500 | NA |
| Climber and epiphyte species | | | | | |
| 1 | <i>Clematis</i> sp. | | Ranunculaceae | | |
| 2 | <i>Crawfordia speciosa</i> C.B.Clarke | | Gentianaceae | 1900-2600 | |
| 3 | <i>Dactylicapnos scandens</i> (D. Don) Hutch | | Papaveraceae | | |
| 4 | <i>Herpetospermum pedunculatum</i> (Seringe.) C.B. Clarke | Ban karela | Cucurbitaceae | 2300-2500 | NA |
| 5 | <i>Piper boechmeriaefolium</i> (Miq.) DC. | Chambo | Piperaceae | 1000-2400 | NA |
| 6 | <i>Rhaphidophora decursiva</i> (Roxb.) Scott | Kanchirna | Araceae | 2000 | NA |
| 7 | <i>Rhaphidophora</i> sp. | Kanchirna | Araceae | | |
| 8 | <i>Rubia cordifolia</i> L. | Manjith | Rubiaceae | 300-2800 | NA |
| 9 | <i>Smilax</i> sp. | Kukur dainey | Smilacaceae | | |
| 10 | <i>Smilax zeylanica</i> Linn. | Kukur dainey | Liliaceae | | |
| 11 | <i>Stephania</i> sp. | Tamarkey | Menispermaceae | 1500-2300 | NA |
| 12 | <i>Tetrastigma serrulatum</i> (Roxb.) Planch | Charchary lahara | Vitaceae | 1800-2500 | NA |
| 13 | <i>Trichosanthes lepiniana</i> (Naudin) Cogn. | Inderani | Cucurbitaceae | 700-2000 | NA |
| Fern and fern-allies species | | | | | |
| 1 | <i>Asplenium lacinum</i> D.Don | | Aspleniaceae | 1000-2500 | NA |
| 2 | <i>Cyathea</i> sp. | | Cyatheaceae | | |
| 3 | <i>Dicranopteris</i> sp. | Sottar | Gleicheniaceae | | NA |
| 4 | <i>Diplazium</i> sp. | Sauney ningro | Athyriaceae | 1700-2500 | NA |
| 5 | <i>Gleichenia gigantean</i> Wall. ex | | Gleicheniaceae | | |

| | | | | | |
|----------------------|--|----------|-----------------|------|----|
| | Hook | | | | |
| 6 | <i>Huperzia</i> sp. | | Lycopodiaceae | | |
| 7 | <i>Lycopodium japonicum</i> Thunb. | Nagbelli | Lycopodiaceae | | |
| 8 | <i>Plagiogyria pycnophylla</i> (Kunze) Mett | | Plagiogyriaceae | | |
| 9 | <i>Selaginella</i> sp. | | Selaginellaceae | 2500 | NA |
| Orchd species | | | | | |
| 1 | <i>Agrostophyllum callosum</i> Rchb.f | | Orchidaceae | | |
| 2 | <i>Bulbophyllum</i> sp. | | Orchidaceae | | |
| 3 | <i>Coelogyne fuscescens</i> Lindl. | | Orchidaceae | | |
| 4 | <i>Coelogyne</i> sp. | | Orchidaceae | | |
| 5 | <i>Cymbidium cochleare</i> Lindl. | | Orchidaceae | | |
| 6 | <i>Cymbidium erythraeum</i> Lindl. | | Orchidaceae | | |
| 7 | <i>Dendrobium longicornu</i> Lindl. | | Orchidaceae | | |
| 8 | <i>Eria coronaria</i> (Lindl.) Rchb.f. | | Orchidaceae | | |
| 9 | <i>Gastrochilus acutifolius</i> (Lindl.) Kunze | | Orchidaceae | | |
| 10 | <i>Gastrochilus inconspicuus</i> (Hook.f.) Kuntze | | Orchidaceae | | |
| 11 | <i>Liparis</i> sp. | | Orchidaceae | | |
| 12 | <i>Otochilus fuscus</i> Lindl. | | Orchidaceae | | |
| 13 | <i>Pleione humilis</i> (Sm.) D. Don | | Orchidaceae | | |
| 14 | <i>Pleione praecox</i> (Smith) D. Don | | Orchidaceae | | |
| 15 | <i>Vanda</i> sp. | | Orchidaceae | | |

Annexure 6: Checklist of floral species recorded along the sampling path of Rayong Reserve Forest, South Sikkim

| S. No | Botanical Name | Local Name | Family | Plant Group | | Life Form |
|---------------------|--|---------------------|-----------------|-------------|---|-----------|
| Tree species | | | | | | |
| 1 | * <i>Acer campbellii</i> Hook.f. & Thomson ex Hiern | Kapasey | Sapindaceae | A | D | P |
| 2 | * <i>Actinodaphne sikkimensis</i> Meisn. | Sissi | Lauraceae | A | D | P |
| 3 | * <i>Alnus nepalensis</i> D.Don | Utis | Betulaceae | A | D | P |
| 4 | * <i>Beilschmiedia sikkimensis</i> King ex Hook.f. | Tarsing | Lauraceae | A | D | P |
| 5 | * <i>Betula alnoides</i> Buch.-Ham. ex D.Don | Saur | Betulaceae | A | D | P |
| 6 | * <i>Brassaiopsis hispida</i> Seem. | Chuletro/Phutta | Araliaceae | A | D | P |
| 7 | * <i>Castanopsis hystrix</i> Hook.f. & Thomson ex A. DC. | Patley katus | Fagaceae | A | D | P |
| 8 | * <i>Castanopsis tribuloides</i> (Sm.) A.DC. | Musrey katus | Fagaceae | A | D | P |
| 9 | * <i>Cryptomeria japonica</i> (Thunb. ex L.f.) D.Don | Dhuppi salla | Cupressaceae | G | | P |
| 10 | <i>Dahlia</i> sp. | | Asteraceae | A | D | P |
| 11 | * <i>Echinocarpus dasycarpus</i> Benth. | Gobre | Elaeocarpaceae | A | D | P |
| 12 | * <i>Elaeocarpus lanceifolius</i> Roxb. | Bhadrase | Elaeocarpaceae | A | D | P |
| 13 | * <i>Engelhardtia spicata</i> Lechen ex Blume | Mauwa | Juglandaceae | A | D | P |
| 14 | * <i>Eurya acuminata</i> DC. | Jhinganey | Pentaphragaceae | A | D | P |
| 15 | * <i>Exbucklandia populnea</i> (R.Br. ex Griff.)R.W.Br. | Piplee | Hamamelidaceae | A | D | P |
| 16 | * <i>Ficus neriifolia</i> Sm. | Dudhilo | Moraceae | A | D | P |
| 17 | * <i>Garuga pinnata</i> Roxb. | Dabdabe | Burseraceae | A | D | P |
| 18 | * <i>Ilex sikkimensis</i> Kurz | Lise | Aquifoliaceae | A | D | P |
| 19 | * <i>Juglans regia</i> L. | Okhar | Juglandaceae | A | D | P |
| 20 | * <i>Leucosceptrum canum</i> Sm. | Ghurpis | Lamiaceae | A | D | P |
| 21 | * <i>Lithocarpus elegans</i> (Blume) Hatus.ex Soepadmo | Arkaulo katus | Fagaceae | A | D | P |
| 22 | * <i>Lithocarpus pachyphyllus</i> (Kurz) Rehder | Sungure katus/Bante | Fagaceae | A | D | P |
| 23 | * <i>Lyonia ovalifolia</i> (Wall.)Drude | Angeri | Ericaceae | A | D | P |
| 24 | * <i>Machilus</i> sp. | Kawlo | Lauraceae | A | D | P |
| 25 | * <i>Magnolia doltsopa</i> (Buch.-Ham. ex DC.)Figlar | Rani champ | Magnoliaceae | A | D | P |
| 26 | * <i>Myrsine semiserrata</i> Wall. | Phalame | Primulaceae | A | D | P |
| 27 | * <i>Prunus bracteopadus</i> Koehne | Arupatey | Rosaceae | A | D | P |
| 28 | * <i>Pyrularia edulis</i> (Wall.) A. DC. | Amphi | Santalaceae | A | D | P |
| 29 | * <i>Quercus</i> sp. | Phalant | Fagaceae | A | D | P |
| 30 | * <i>Quercus lamellosa</i> Sm. | Buk/Bajranth | Fagaceae | A | D | P |

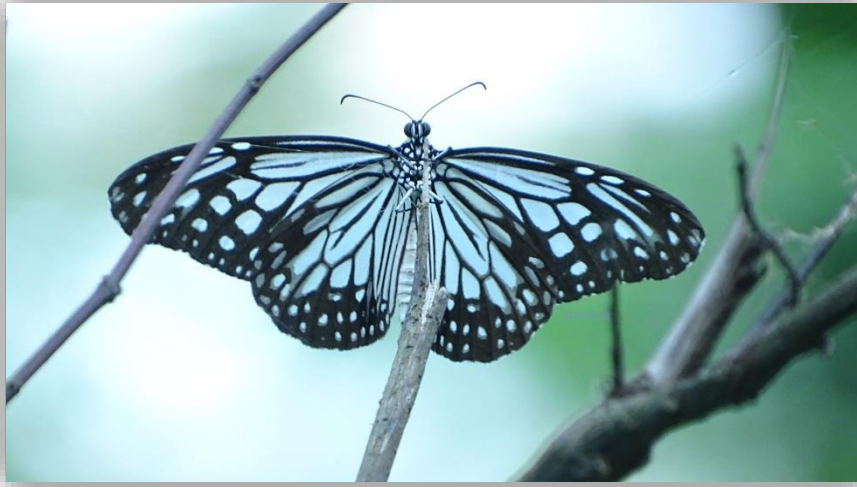
| | | | | | | |
|---------------------|--|------------------|-----------------|---|---|---|
| 31 | <i>*Rapanea capitellata</i> (Wall.) Mez | Setikath | Primulaceae | A | D | P |
| 32 | <i>*Symplocos glomerata</i> King ex C.B. Clarke | Kholmey | Symplocaceae | A | D | P |
| 33 | <i>*Symplocos lucida</i> (Thunb.) Siebold & Zucc. | Kharanay | Symplocaceae | A | D | P |
| 34 | <i>*Toona sureni</i> (Blume) Merr. | Tooni | Meliaceae | A | D | P |
| 35 | <i>*Toxicodendron hookeri</i> (K.C. Sahni & Bahadur) C.Y. Wu & T.L. Ming | Bhalayo | Anacardiaceae | A | D | P |
| 36 | <i>*Tsuga dumosa</i> (D.Don) Eichler | Thinge salla | Pinaceae | G | | P |
| 37 | *Unidentified | Halunday | | A | D | P |
| 38 | <i>*Zanthoxylum acanthopodium</i> DC. | Boke timmur | Rutaceae | A | D | P |
| Herb species | | | | | | |
| 1 | <i>*Ageratina adenophora</i> (Spreng.) R.M.King & H.Rob. | Banmara/Kalijhar | Asteraceae | A | D | H |
| 2 | <i>Anaphalis busua</i> (Buchanan-Hamilton ex D. Don) de Candolle | Bukiphool | Asteraceae | A | D | T |
| 3 | <i>*Anaphalis margaritacea</i> (L.) Benth. & Hook.f. | Bukiphool | Asteraceae | A | D | T |
| 4 | <i>Anaphalis triplinervis</i> (Sims) Sims ex C.B.Clarke | Bukiphool | Asteraceae | A | D | T |
| 5 | <i>Aster</i> sp. | | Asteraceae | A | D | H |
| 6 | <i>Astilbe rivularis</i> Buch.-Ham. ex D.Don | Buro okhati | Saxifragaceae | A | D | C |
| 7 | <i>Begonia dioica</i> Buchanan-Hamilton ex D. Don | Magar kajey | Begoniaceae | A | D | G |
| 8 | <i>*Begonia tessaricarpa</i> C.B. Clarke | Magar kajey | Begoniaceae | A | D | G |
| 9 | <i>*Bidens pilosa</i> L. | Tikhe kuro | Asteraceae | A | D | T |
| 10 | <i>*Boenninghausenia albiflora</i> (Hook.) Rchb. ex Meisn. | Dampate, Ankuree | Rutaceae | A | D | C |
| 11 | <i>Calceolaria</i> sp. | Lady's purse | Calceolariaceae | A | D | H |
| 12 | <i>*Carex</i> sp. | Salimo | Cyperaceae | A | M | H |
| 13 | <i>Centella asiatica</i> (L.) Urb. | Golpatta | Apiaceae | A | D | H |
| 14 | <i>Clinopodium umbrosum</i> (M. Bieberstein) C. Koch | | Labiataeae | A | D | H |
| 15 | <i>*Cynodon dactylon</i> Linn. | Dubo | Poaceae | A | M | H |
| 16 | <i>Disporum</i> sp. | Mahjari | Colchicaceae | A | M | H |
| 17 | <i>*Elatostema platyphyllum</i> Wedd. | Sano gagleto | Urticaceae | A | D | T |
| 18 | <i>Elatostema</i> sp. | Gagleto | Urticaceae | A | D | T |
| 19 | <i>*Eragrostis</i> sp. | Banso | Poaceae | A | M | H |
| 20 | <i>*Fragaria nubicola</i> (Lindl. ex Hook.f.) Lacaite | Bhui ainselu | Rosaceae | A | D | H |
| 21 | <i>Gaultheria</i> sp. | | Ericaceae | A | D | C |
| 22 | <i>*Gaultheria nummularioides</i> D. Don, | | Ericaceae | A | D | C |
| 23 | <i>Gentiana capitata</i> Buch.-Ham. ex D.Don | | Gentianaceae | A | D | H |
| 24 | <i>*Girardinia diversifolia</i> (Link) Friis | Bhangray sisnu | Urticaceae | A | D | C |
| 25 | <i>*Hedychium gardnerianum</i> Sheppard ex | Saro | Zingiberaceae | A | M | G |

| | | | | | | |
|----------------------|---|--|----------------|---|---|---|
| | Ker Gawl | | | | | |
| 26 | <i>*Hedychium spicatum</i> Sm. | Saro | Zingiberaceae | A | M | G |
| 27 | <i>*Hemiphragma heterophyllum</i> Wall. | Lalgeri/Nash Jhaar, Lahare Phool, Raato Gedi | Plantaginaceae | A | D | T |
| 28 | <i>Houttuynia cordata</i> Thunberg | Gadhey jhar | Saururaceae | A | D | H |
| 29 | <i>*Hydrocotyle nepalensis</i> Hooker f., Exot | | Apiaceae | A | D | H |
| 30 | <i>*Impatiens racemosa</i> DC. | Tantari, Anchirna | Balsaminaceae | A | D | T |
| 31 | <i>*Lecanthus peduncularis</i> (Wall. ex Royle) Wedd. | | Urticaceae | A | D | T |
| 32 | <i>*Oxalis corniculata</i> Linn. | Amilo jhar | Oxalidaceae | A | D | C |
| 33 | <i>*Persicaria runcinata</i> (Buch. – Ham. ex D.Don.) MAssam. | Ratnaulo | Polygonaceae | A | D | H |
| 34 | <i>*Persicaria capitata</i> (Buch.-Ham. ex D.Don) H.Gross | Ratnaulo | Polygonaceae | A | D | T |
| 35 | <i>Persicaria chinensis</i> (L.) H. Gross | Thotney | Polygonaceae | A | D | C |
| 36 | <i>*Persicaria wallichii</i> Greuter & Burdet | Rani thotney (like shrub) | Polygonaceae | A | D | G |
| 37 | <i>*Pilea scripta</i> (Buch.-Ham. ex D. Don) Wedd. | Chiplej jhar | Urticaceae | A | D | T |
| 38 | <i>Pilea umbrosa</i> Weddell ex Blume | Chiplej jhar | Urticaceae | A | D | T |
| 39 | <i>*Polygonum molle</i> D. Don | Thotney | Polygonaceae | A | D | P |
| 40 | <i>*Rohdea nepalensis</i> (Raf.) N.Tanaka | Nakima | Asparagaceae | A | M | G |
| 41 | <i>*Rubus calycinus</i> Wall. ex D.Don | Bhui ainselu | Rosaceae | A | D | H |
| 42 | <i>*Strobilanthes</i> sp. | Kibu ghans | Acanthaceae | A | D | H |
| 43 | <i>*Swertia chirayita</i> (Roxb. ex Fleming) H. Karst. | Chirowto | Gentianaceae | A | D | H |
| 44 | <i>*Swertia bimaculata</i> (Siebold & Zucc.) Hook. f. & Thomson ex C.B. Clarke | Bhaley chirowto | Gentianaceae | A | D | H |
| 45 | <i>*Urtica parviflora</i> Roxb. | Patley sisnu | Urticaceae | A | D | G |
| 46 | <i>*Urtica dioica</i> L. | Gharia sisnu | Urticaceae | A | D | T |
| 47 | <i>*Viola</i> sp. | | Violaceae | A | D | T |
| Shrub species | | | | | | |
| 1 | <i>*Ardisia macrocarpa</i> Wall. | Damai daana | Primulaceae | A | D | P |
| 2 | <i>Cestrum</i> sp. | | Solanaceae | A | D | C |
| 3 | <i>*Cotoneaster</i> sp. | | Rosaceae | A | D | C |
| 4 | <i>*Daphne papyracea</i> Wall. ex G. Don | Kalo argeli | Thymelaeaceae | A | D | P |
| 5 | <i>*Dichroa febrifuga</i> Lour. | Bhaasak, Bansuli, Ganhaaune Paat, Aseru, Banasuk | Hydrangeaceae | A | D | P |
| 6 | <i>*Gaultheria</i> sp. | | Ericaceae | A | D | C |
| 7 | <i>*Ilex</i> sp. | | Aquifoliaceae | A | D | P |
| 8 | <i>Lysionotus</i> sp. | | Gesneriaceae | A | D | C |
| 9 | <i>*Mahonia napaulensis</i> DC. | Kesari | Berberidaceae | A | D | P |

| | | | | | | |
|-------------------------------------|---|--------------------------------|-----------------|----|---|---|
| 10 | <i>Neillia rubiflora</i> D. Don | Kirkirey jhar | Rosaceae | A | D | C |
| 11 | * <i>Osbeckia stellata</i> Buch.-Ham. ex Ker Gawl. | Lote jhar | Melastomataceae | A | D | P |
| 12 | * <i>Rubus paniculatus</i> Sm. | Bhalu aiselu | Rosaceae | A | D | P |
| 13 | * <i>Rubus parviflorus</i> | Aiselu | Rosaceae | A | D | P |
| 14 | <i>Rubus</i> sp. | Aiselu | Rosaceae | A | D | P |
| 15 | * <i>Rubus ellipticus</i> Sm. | Aiselu | Rosaceae | A | D | P |
| 16 | * <i>Viburnum erubescens</i> Wall. | Asare | Adoxaceae | A | D | P |
| 17 | * <i>Solanum aculeatissimum</i> Jacq. | Boksi kara | Solanaceae | A | D | P |
| Fern and fern-allies species | | | | | | |
| 1 | * <i>Allantodia maxima</i> (D. Don) Ching | Sawney ningro / bhadore ningro | Athyriaceae | Pt | | G |
| 2 | * <i>Belvisia henryi</i> (Hieron. ex C. Chr.) Raymond | Needle fern or Tailed fern | Polypodiaceae | Pt | | G |
| 3 | <i>Cyathea chinensis</i> Copel. | Rukh uniu | Cyatheaceae | Pt | | P |
| 4 | <i>Cyathea</i> sp. | Bhoot ningro | Cyatheaceae | Pt | | P |
| 5 | * <i>Diplazium dilatatum</i> | Lek Chipley Ningro | Athyriaceae | Pt | | G |
| 6 | * <i>Diplazium</i> sp. | Singaray ningro | Athyriaceae | Pt | | G |
| 7 | <i>Dryopteris redactopinnata</i> Basu and Panigrahi | | Dryopteridaceae | Pt | | G |
| 8 | * <i>Gleichenia longissima</i> Blume | Kalamey uniu | Gleicheniaceae | Pt | | G |
| 9 | * <i>Goniophlebium argutum</i> (Wall. ex Hook.) J. Sm. ex Hook. | | Polypodiaceae | Pt | | G |
| 10 | * <i>Lepisorus longifolius</i> (Blume) Holttum | | Polypodiaceae | Pt | | G |
| 11 | * <i>Lycopodium japonicum</i> Thunb. | Nagbeli | Lycopodiaceae | Pt | | G |
| 12 | * <i>Nephrolepis cordifolia</i> (L.) C. Presl. | Pani amla | Oleandraceae | Pt | | G |
| 13 | * <i>Pteris biaurita</i> | Thare unew | Pteridaceae | Pt | | G |
| 14 | <i>Pteris wallichiana</i> J. Agardh | Chatey uniu | Pteridaceae | Pt | | G |
| 15 | * <i>Selaginella</i> sp. | Sindure | Selaginellaceae | Pt | | T |
| Climber and epiphyte species | | | | | | |
| 1 | <i>Aeschynanthus</i> sp. | | Gesneriaceae | A | D | P |
| 2 | <i>Agapetes incurvata</i> (Griffith) Sleumer | | Ericaceae | A | D | P |
| 3 | * <i>Agapetes serpens</i> (Wight) Sleumer | | Ericaceae | A | D | P |
| 4 | <i>Cissus elongata</i> Roxb. | Charcharey lahara | Vitaceae | A | D | P |
| 5 | * <i>Clematis buchananiana</i> DC. | Pinasey lahara | Ranunculaceae | A | D | P |
| 6 | <i>Dactylicapnos scandens</i> (D. Don) Hutch. | Lahara | Papaveraceae | A | D | P |
| 7 | <i>Herpetospermum pedunculatum</i> (Ser.) C.B. Clarke | Ban karela | Cucurbitaceae | A | D | P |
| 8 | * <i>Hoya linearis</i> Wall. ex D. Don | | Apocynaceae | A | D | P |
| 9 | <i>Peperomia</i> sp. | | Piperaceae | A | D | P |
| 10 | <i>Piper boehmeriifolium</i> (Miq.) Wall. ex C. DC. | Chambo / Panpatta | Piperaceae | A | D | P |

| | | | | | | |
|--|---|----------------------------|----------------|---|---|---|
| 11 | <i>Rhaphidophora decursiva</i> (Roxb.) Schott | Kanchirno | Araceae | A | M | P |
| 12 | * <i>Rubia manjith</i> Roxb. ex Fleming | Majito | Rubiaceae | A | D | P |
| 13 | <i>Smilax zeylanica</i> L. | Kukur dainey/Datuin lahara | Smilacaceae | A | D | P |
| 14 | <i>Stephania elegans</i> Hook. f. & Thomson | Tamarke lahara | Menispermaceae | A | D | P |
| 15 | * <i>Tetrastigma</i> sp. | | Vitaceae | A | D | P |
| 16 | * <i>Tetrastigma serrulatum</i> (Roxb.) Planch. | Charcharey lahara | Vitaceae | A | D | P |
| 17 | * <i>Trichosanthes lepiniana</i> (Naudin) Cogn. | Indreni | Cucurbitaceae | A | D | P |
| Orchid species | | | | | | |
| 1 | <i>Coelogyne corymbrosa</i> | Sunakhari | Orchidaceae | A | M | H |
| 2 | <i>Coelogyne fuscescens</i> Lindl. | | Orchidaceae | A | M | H |
| 3 | <i>Dendrobium longicornu</i> Lindl. | | Orchidaceae | A | M | H |
| 4 | <i>Eria coronaria</i> (Lindl.) Rchb.f. | | Orchidaceae | A | M | H |
| 5 | <i>Otochilus fuscus</i> Lindl. | | Orchidaceae | A | M | H |
| 6 | <i>Pleione praecox</i> (Sm.) D.Don | | Orchidaceae | A | M | H |
| Bamboo species | | | | | | |
| 1 | <i>Yushania maling</i> (Gamble) R.B.Majumdar & Karthik. | Malingo | Poaceae | A | M | P |
| 2 | <i>Himalayacalamus hookerianus</i> (Munro) Stapleton | Pareng/Paryang | Poaceae | A | M | P |
| 3 | <i>Himalayacalamus falconeri</i> (Hook.f. ex Munro) Keng f. | Singanay baas | Poaceae | A | M | P |
| Note: A, Angiosperm; G, Gymnosperm; D, Dicotyledon; M, Monocotyleon; Pt, Pteridophytes; P, Phanerophyte; H, Hemicryptophyte; C, Chaemephyte; G, Geophyte; T, Therophyte | | | | | | |

Butterfly species

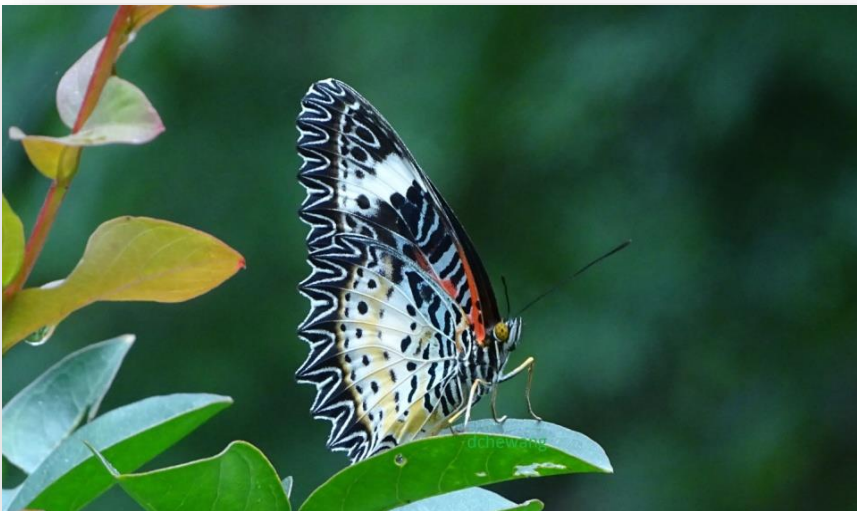


Chocolate Tiger

Parantica aglea melanoleuca

Nymphalidae

Commonly seen upto 2100m
asl



Leopard Lacewing (Female)

Cethosia cyane

Nymphalidae

Commonly seen upto 4500m asl



Stately Nawab

Polyura dolon

Nymphalidae

Commonly seen upto 1900m asl



Glassy Bluebottle
Graphium cloanthus
Papilionidae
Commonly seen upto
2700m asl



Golden Sapphire
Heliophorus brahma
Lycaenidae
Commonly seen upto 2500m asl



Green Commodore
Sumalia daraxa
Nymphalidae
Commonly seen upto
2100m asl



Yellow Helen
Papilio nephelus
Papilionidae



Common Jester
Symbrenthia lilaea
Nymphalidae
Commonly seen upto 1700m
asl



Large silverstripe
Argynnis children
Nymphalidae
Commonly seen upto 3000m
asl



Punchinello
Zemeros flegyas
Riodinidae
Commonly seen upto 2300m asl



Treble Silverstripe
Lethe baladeva
Nymphalidae
Commonly seen upto 2200m



Blank Swift
Caltoris kumara
Hesperiidae
Commonly seen upto 1900m asl

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