CHAPTER 3

VEGETATION DESCRIPTION OF THE STUDY AREA

3.1 Introduction

Information and description of the vegetation community allows a better insight into animal-habitat relationship and the importance of it is being increasingly realised and applied (Diernstein, 1979; Shretha, 1988; Higgins *et al.*, 1994; Sharma, 1994; Khan, 1996;). Since changes in vegetation influence the distribution and abundance of animal species, it helps in understanding the dynamics of animal population distribution, abundance and habitat use (Diernstein,1979; Gopal and Mehr Homji, 1986). Thus, such investigations form the basis for conservation and management. Examples of very detailed study of habitat and its restoration can be found in case of study of the giant panda in China (Reid *et* al.1989; Taylor and Zisheng, 1987; Taylor and Zisheng, 1988 a; Taylor and Zisheng, 1988 b; Taylor and Zisheng, 1988 c; Taylor and Zisheng, 1989).

No major quantitative analysis of vegetation has been done in the Singhalila National Park before this study. The vegetation of this area has also been subjected to intense human disturbance and as a result is greatly modified. It was thus important to have an updated knowledge of the vegetation of the area which the red panda and other fauna inhabit. This study of vegetation was taken up as a part of habitat study of the red panda in the Singhalila National Park.

An understanding of the phenological events in a forest community may reveal the structural organisation of various types of resources (Shukla and Ramakrishnan, 1982) and an appraisal of the functioning of the ecosystem (Prasad and Malati, 1986). Thus a phenological study was also undertaken in order to have a better understanding of the spatial and temporal availability of food and cover to the red panda and other fauna in the study area.

This chapter deals with the description of the structure, composition and classification, phenological or the functional aspect of vegetation and the various anthropogenic pressures on the vegetation in the study area.

3.2 Methods

3.2.1 Vegetation sampling

Sampling of vegetation of the intensive study area comprising Gairibans, Kalipokhari and Sandakphu was carried out in September-October 1995. Sampling was done at seven different altitudinal limits (2700 m, 2850 m, 3000 m, 3150 m, 3300 m, 3450 m and 3600 m) by systematically placing 10 x 10 m quadrats placed at 100 m distance from each other. In each quadrat, total number of trees ($\geq$31.5 cm in gbh- girth at breast height) were recorded. Apart from these, other parameters recorded percent cover, height and gbh of the trees. Seedling ($\leq$30 cm in height), Sapling I (>30 cm to <1m in height), sapling II ($\leq$31 cm gbh and >1m height), shrub species, their number and percent shrub cover, bamboo species and bamboo cover (grazed and ungrazed bamboo), were quantified by placing 3 x 3 m quadrats within the 10 x 10 m plots.

Nomenclature for plants follow Cowan and Cowan (1929) and Stanion and Pollulin (1984).

Assessment of disturbance to the Park was done by quantifying the current grazing and lopping pressures, past disturbances of grazing and lopping, presence of cattle paths, damage done by presence of roads, paths, settlements in the park vicinity, fire, landslips and erosions. All these factors of disturbance were estimated subjectively on ordinal scales of 0= absent, 1= low, 2= medium and 3=high. The number of cut stumps were counted within the 10 x 10 m quadrat and density calculated per hectare.

3.2.2 Categorisation of size classes

Based on the gbh recorded in the sampling quadrat, trees were categorised into three size classes, that of- trees with gbh ≥31-70 cm, ≥70-150 cm and ≥150 . Size classes of trees along with the seedling and the saplings were used to explain the forest structure. Thus five size classes used in the text are-

Size class 1= Seedling

Size class 2 = Sapling (sapling I and sapling II were pooled)

Size class 3 = trees ≥31 - 70 cm

Size class 4 = trees ≥70 - 150 cm and

Size class 5 = trees ≥150.

3.2.3 Phenology: Phenophases of 24 species of trees (13 evergreen species and 11 decidious), six species of shrubs and a few creepers (Appendix III) were studied. A total of ten individuals of each tree, shrub and creeper species were marked in March 1995 for the phenological study and data were collected till October 1996. Data were collected on a monthly basis on various phenophases such as leaf buds, young leaves, mature leaves, flower buds, accession of flowers, abscission of flowers, fruit buds, immature fruits, mature fruits and abscission of fruits. A rating of 0 = absent, 1= common, 2 = very common, 3 = abundant was assigned to the phenophases following Baranga (1986). These scores were converted into 0 to 1scale by dividing the scores with the highest score. These were then averaged for each phenophase for each month by dividing with the total number of tree species studied and the result expressed in percentage.

3.3 Analyses

The important measurable quantities to describe a community are density, frequency and cover or basal area (Mueller-Dombois and Ellenberg, 1974). The data collected during the present study were analysed for abundance, density and frequency. Basal area or the area occupied by a species was determined from the gbh of the trees. The Importance Value Index (IVI) for the tree species was determined by summing the values of relative frequency, relative density and relative dominance (Curtis, 1959). The relative frequency, relative density and relative dominance were determined following Curtis and McIntosh (1950).

$$\text{Relative frequency} = \frac{\text{Frequency of one species}}{\text{Sum of all frequencies}} \times 100$$

$$\text{Relative density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Combined basal area of a single species}}{\text{Total basal area of all species}} \times 100$$

Diversity was calculated following the Shannon-Wiener's index (Greg-Smith, 1983; Shannon and Wierner,1963).

$$H' = -\sum p_i \times \log p_i$$

where,

p_i is the proportion of i^{th} species and H' is the Shannon Wiener diversity index.

Species richness was determined by the Margalef's richness index (Magurram, 1988): $D_{Mg} = (S - 1) / \ln N$

Where,

S = Number of species, N = Number of Individuals of all species and D_{mg} is species richness.

Vegetation classification of the study area was done using Cluster analysis following Causton (1988). This technique is an agglomerative classification, which groups together, individuals possessing greatest similarity in terms of the attributes used to characterise them (Ferrar and Walker, 1974; Strauss, 1982). The average linkage clustering strategy was adopted to classify the vegetation along the altitudinal gradients of the study area using SYSTAT 4.0 (1988).The cluster analysis was performed on data matrix of the Importance Value Index of the tree species with altitudes as columns and Importance Value Index values of thirty five species as rows.

In order to understand the structure of the forest, the density of each species of trees in each diameter class or size class (section 3.2.2 of this chapter) was computed following Bargali *et al.* (1989). The Non-parametric tests used were done using Stata 5.0 (1997).

3.4 Results

3.4.1 Tree layer and Classification: Details of Importance value index (IVI) of tree species are presented in Table 3.1. The cluster analysis produced four distinct clusters of vegetation communities corresponding to the vegetation in different altitudinal zones (Figure 3.1). The entire data set was divided into two major categories **A** and **B.** Category **A**, consists of two clusters **a** and **b**. Cluster **a** has altitude 2700 m and cluster **b** has altitudes 2850 and 3000 m. Category **B** consists of two clusters- **c** and **d.** Cluster **c** comprises of altitudes 3150 m and 3300 m while cluster **d** has altitudes 3450 m and 3600 m.

Cluster **a** which represents altitude of 2700 m has *Quercus pachyphylla* as the most dominant species with an IVI of 81.15. Dominant undercanopy species are *Rhododendron arboreum* (IVI 32.10), *Litsaea elongata* (IVI 55.02) and *Schefflera impressa* (IVI 36.34). This cluster represents the Oak Forest which is found within

Table 3.1 Importance Value Index of tree species at different altitudes of the study area.

Tree species	2700m	2850m	3000m	3150m	3300m	3450m	3600m
Abies densa	0	0	0	67.59	69.70	185.2	24.6
Betula utilis	0	0	0	32.34	126.49	56.41	84.51
Rhodorendron arboreum	32.10	41.00	25.55	93.15	49 49	26.92	0
Rhodorendron campanulatum	0	0	0	0	0	17.02	93.35
Rhodorendron falconeri	17.58	9.70	33.13	9.37	0	0	0
Andromeda villosa	0	0	0	12.75	0.	0	0
Sorbus microphylla	0	0	0	0	0	0	23.42
Meliosma dilleniaefolia	0	7.37	10.55	9.08	0	0	0
Tsuga brunoniana	0	0	0	14.15	0	0	0
Viburnum nervosum	0	0	0	17.30	0	0	0
Sorbus cusnidata	5.99	48.61	50.55	12.78	0	0	0
Litsaea sericera	20.91	5.64	28.43	19.35	0	0	0
Buddleia asiatica	0	0	5.26	12.78	0	0	0
Andromeda formosa	0	0	0	0	11.71	0	0
Symplocus sp	2.52	58.42	73.11	0	0	0	0
Osmanthus sauvis	7.99	31.97	14.97	0	0	0	0
Ilex hookeri	4.87	27.42	0	2.37	0	0	0
Endospermum chinense	24.31	5.64	0	0	0	0	0
Acer campbellii	13.97	29.42	20.80	0	0	0	0
Acer pectinatum	0	0	0	5.96	0	0	0
Quercus pachyphylla	81.15	43.04	0	0	0	0	0
Marelo*	2..52	10.95	0	0	0	0	0
Viburmun erubescens	0	7.84	12.70	0	0	0	0
Magnolia campbellii	17.13	11.32	0	0	0	0	0
Vitex heterophylla	7.69	11.32	0	0	0	0	0
Schefflera impressa	36.34	11.32	0	0	0	0	0
Litsaea elongata	55.02	0	0	0	0	0	0
Eurya japonica	2.92	0	0	0	0	0	0
Corylus forex	2.92	0	0	0	0	0	0
Rhodorendron barbatum	0	0	0	11.77	30.28	0	0
Rhodorendron thomsoni	0	0	0	0	0	15.34	0
Rhodorendron cinnabarium	0	0	20.84	19.21	0	0	0
Rhodorendron cinnamomeum	0	0	0	0	21.49	0	0
Rhodorendron griffithianum	17.20	0	0	0	0	0	0

* = local name

2600 m-2800 m in the study area. Cluster **b** has *Sorbus cuspidata* as the dominant uppercanopy species (IVI 48.61) in association with *Quercus* sp. (IVI 43.040), *Acer campbellii* (IVI 29.42) and *Vitex heterophylla* (IVI 11.32) at the lower altitudes but this association gradually gives way to a composition where the IVI of *Quercus* sp. is zero. The uppercanopy at 3000 m is mostly deciduous with *Sorbus cuspidata* (IVI 50.55), *Acer campbellii* (IVI 20.80). *Rhododendron falconeri* commonly known as Korlinga forms both the upper and undercanopy in these altitudes and has an IVI value of 33.13. Undercanopy, dominantly has *Symplocos* sp. (IVI 58.42 and 73.11 at 2850 m and 3000 m respectively), *Osmathus sauvis* (IVI 31.97 and 14.69 at 2850 m and 3000 m respectively), *Rhododendron arboreum* (IVI 41.00 and 25.55 at 2850 m and 3000 m respectively), *Meliosma dilleniaefolia* (7.37 and 10.55 at 2850 m and 3000 m respectively). This cluster represents the Broad-leafed deciduous forest which is found within the altitudinal range of >2800 m-3100 m in the study area.

In cluster **c**, the dominant uppercanopy species are *Abies densa* (IVI 67.59) and *Betula utilis* (IVI 32.34), in association with *Litsaea* sp. (IVI 19.35), *Tsuga brunoniana* (IVI 14.15), *Sorbus cuspidata* (IVI 12.78), *Acer pectinatum* (IVI 5.96) at the lower altitudinal range, which is represented by 3150 m. With an increase in altitude, that is above 3150 m, *Abies densa* (IVI 69.70) is still the dominant species but with an association of *Betula utilis* (IVI 126.49). Other deciduous trees such as the *Sorbus cuspidata, Acer* and *Litsaea* species are not found. *Tsuga brunoniana* was found sparsely, only in sapling and seedling stages at 3300 m and above. The undercanopy consisted of *Rhododendron arboreum, Rhododendron cinnamomeum, Andromeda villosa, Meliosma delleniaefolia, Buddleia asiatica* in the lower ranges but *A. villosa,*

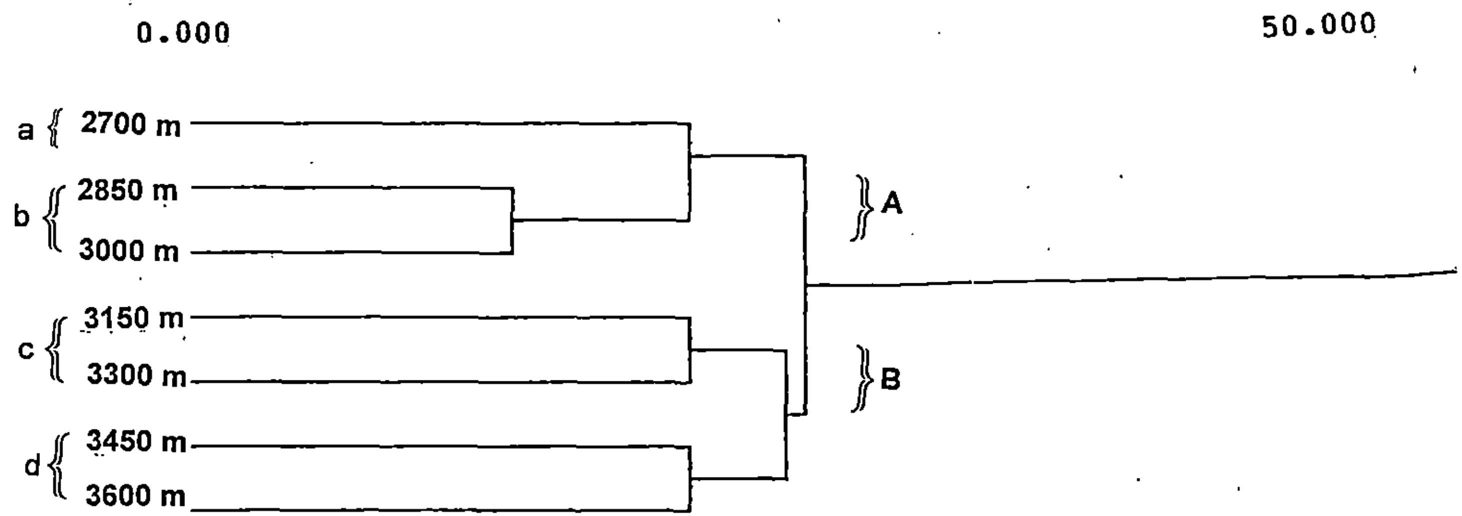


Fig. 3.1 Classification of the vegetation of the study area based on importance value index of tree species at different altitudes

a = Oak forest

b = Broad-leafed deciduous forest

c = Broad-leafed coniferous forest

d = Coniferous forest

A = SUBALPINE ZONE

B = TEMPERATE ZONE

M. dilleniaefolia, *B. asiatica* (the IVI are presented in the Table 3.1, all deciduous species were not found in the higher altitudes (i.e. 3300 m and above). This cluster represents Broad-leafed coniferous forest, which is within an altitudinal range of >3150 m-3300 m in the study area.

Cluster **d** represented by altitudes 3450 m and 3600 m also has *Abies densa* (IVI 185.25) at 3450 m and (IVI 124.63) at 3600 m as the dominant tree species. *Betula utilis* (IVI 56.41) and *Rhododendron arboreum* (IVI 26.92) are the undercanopy species at 3450 m. *Rhododendron arboreum* becomes absent and *Rhododendron campanulatum* (IVI 93.35) dominates towards the higher reaches, i.e. 3600 m. The broad-leafed deciduous species in addition to *Betula utilis* present in this zone are *Andromeda formosa* and *Sorbus microphylla*. This cluster represents Coniferous forest found within an altitude >3500 m-3600 m in the study area.

From these groupings it is apparent that category **A** represents the temperate zone while category **B** represents the subalpine zone. Therefore, there are four distinct vegetation zones in the study area. They are Oak forest (2600 m-2800 m), Broad-leaf deciduous forest (>2800 m-3100 m), Broad-leaf coniferous forest (>3150 m-3300 m) and Coniferous forest (>3300 m-3600 m).

Dendrograms of the tree species in the four vegetation zones are presented in Figures 3.2, 3.3, 3.4, 3.5 (Distance value of zero in the figures indicate minimum dissimilarity in the IVI values and distance value of 50 or 100 indicate maximum dissimilarity in the IVI values of the tree species).

1 = *R. arboeum*
2 = *R. falconeri*
3 = *S. cuspidata*
4 = *L. sericera*
5 = *Symplocos* sp.
6 = *O. sauvis*
7 = *I.lex* sp.
8 = *E. chinensese*
9 = *A. campbellii*
10 = *Q. pachyphylla*
11 = Marelo
12 = *M. campbellii*
13 = *V. heterophylla*
14 = *S. impressa*
15 = *L. elongata*
16 = *E. japonica*
17 = *R. griffithianum*

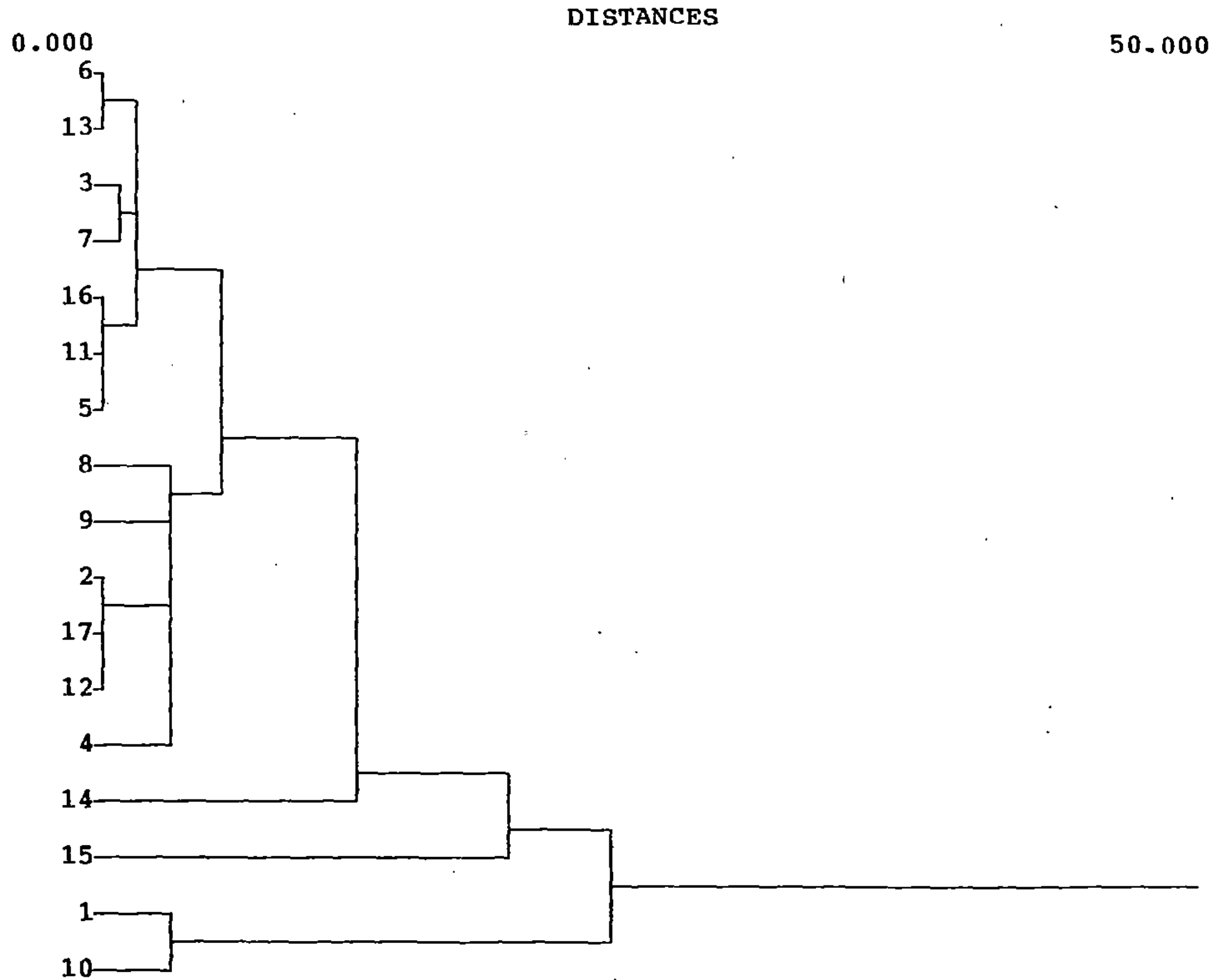


Fig 3.2 Dendrogram of tree species in Oak forests (2600-2800 m)

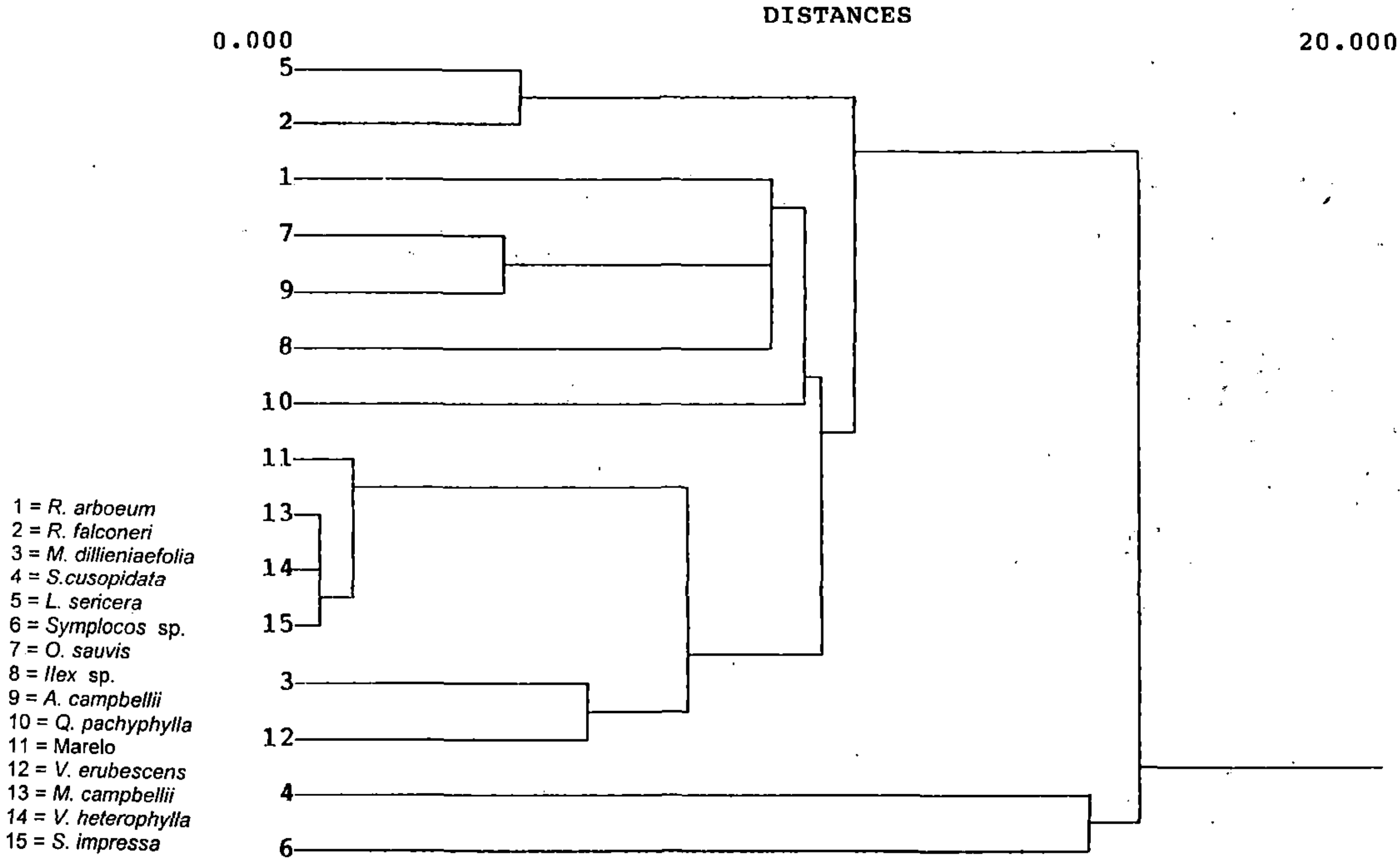
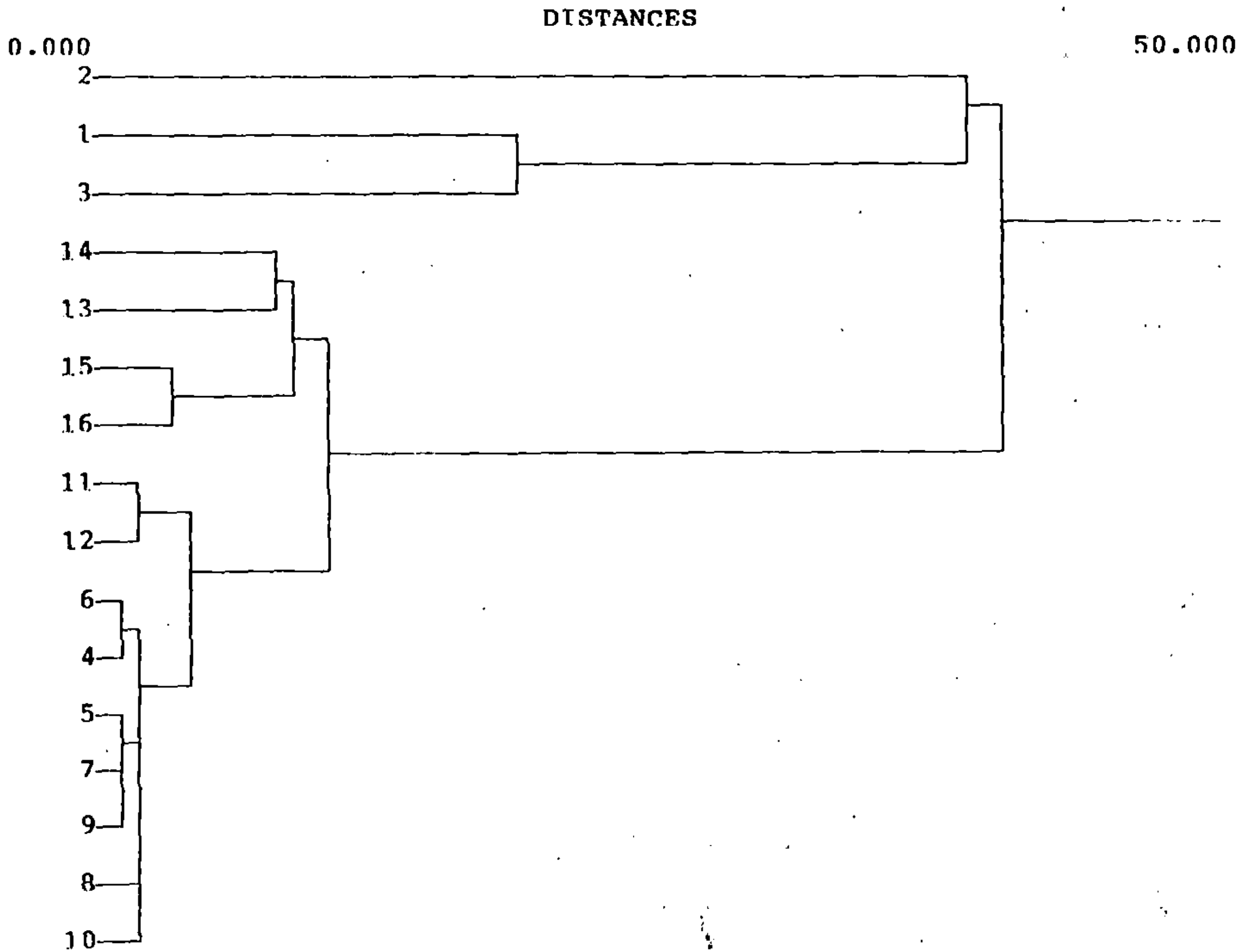


Fig 3.3 Dendrogram of tree species in Broad-leafed deciduous forest (>2800-3100 m)



1 = *A. densa*
2 = *B. utilis*
3 = *R. arboreum*
4 = *R. falconeri*
5 = *A. formosa*
6 = *M. dellinifolia*
7 = *T. brunoniana*
8 = *V. nervosum*
9 = *S. cuspidata*
10 = *L. sericera*
11 = *lex* sp.
12 = *A. campbellii*
13 = *R. barbatum*
14 = *R.cnnabarium*
15 = *R. cinnamomeum*
16 = *R.thomsoni*

Fig 3.4 Dendrogram of tree species in Broad-leafed coniferous forest (>3100-3300 m)

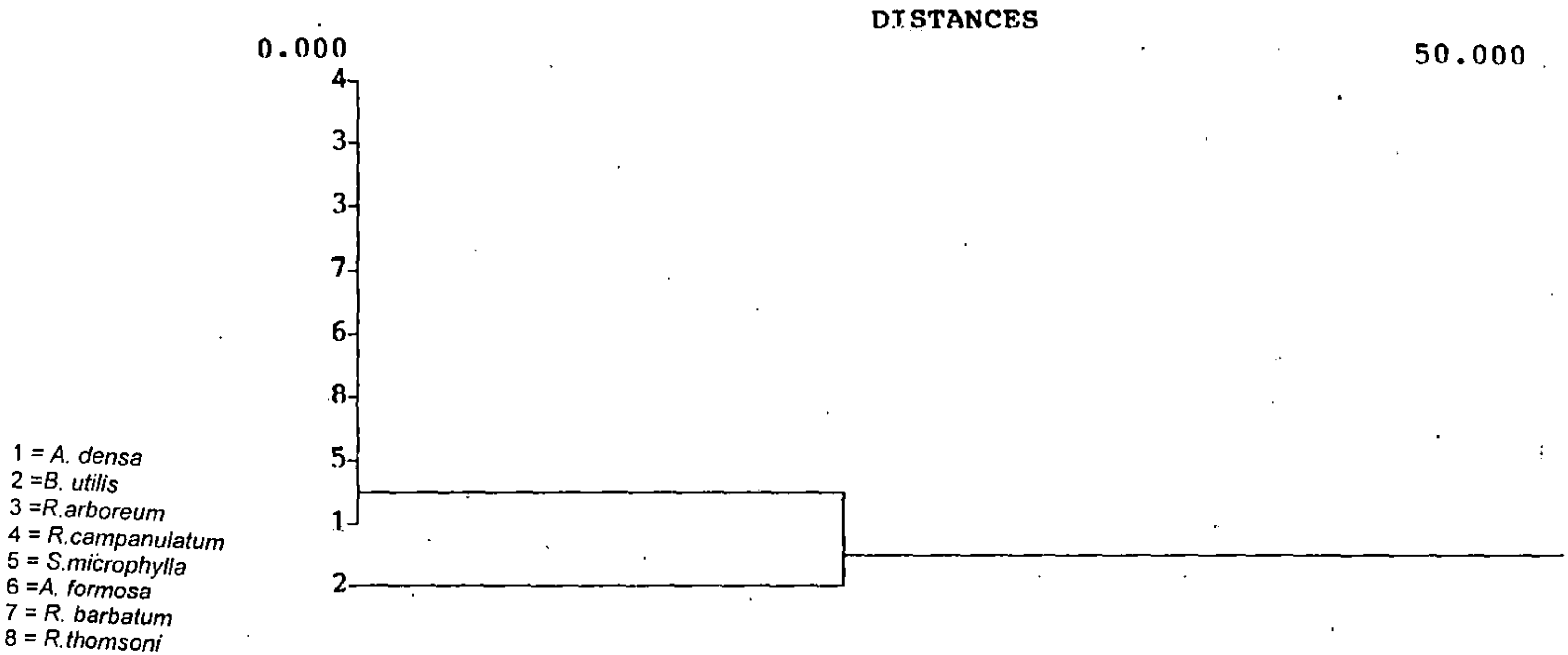


Fig 3.5 Dendrogram of the tree species in Coniferous forest (>3300-3600 m)

Relative density for certain dominant tree species were plotted against the altitudinal gradients (Figure 3.6) following Saxsena *et al.* (1982) to show their distribution. It shows that the dominant species of different forest types at their corresponding altitudes are widely distributed outside their own forest types also. *Quercus pachyphylla* is most abundant at 2700 m but its distribution is found to extend into Broad-leaf deciduous forest. Distribution of *Sorbus cuspidata* also extends from Oak forest into Broad-leaf coniferous forest, with its peak of abundance in the Broad-leaf deciduous forest. Such overlaps in the vegetation occur not only amongst the dominant tree species but can be found among the understorey species and shrubs which forms a continumm in the vegetation.

The density of trees was found to be highest at 2700 m and lowest at 3600 m. Species diversity ranged from 0.18 to 1.16. Richness was also higher in the lower altitudes which decreased towards the higher altitudes. The general trend was of a gradual decrease of all the three attributes with altitude but the values of density, diversity and richness of the tree species at 3000 m were lower as compared to 3150 m (Table 3.2).

3.4.2 Sapling and seedlings

The results of sapling and seedling densities of tree species at different altitude gradients of the study area are provided in Table 3.3 and 3.4. Regeneration of the dominant species like *Quercus* sp., *Magnolia campbellii* and *Acer campbellii* were found to be low as evidenced by the lower density of the seedling and saplings as compared to that of the undercanopy species *Litsaea elongata* at 2700 m. *Sorbus*

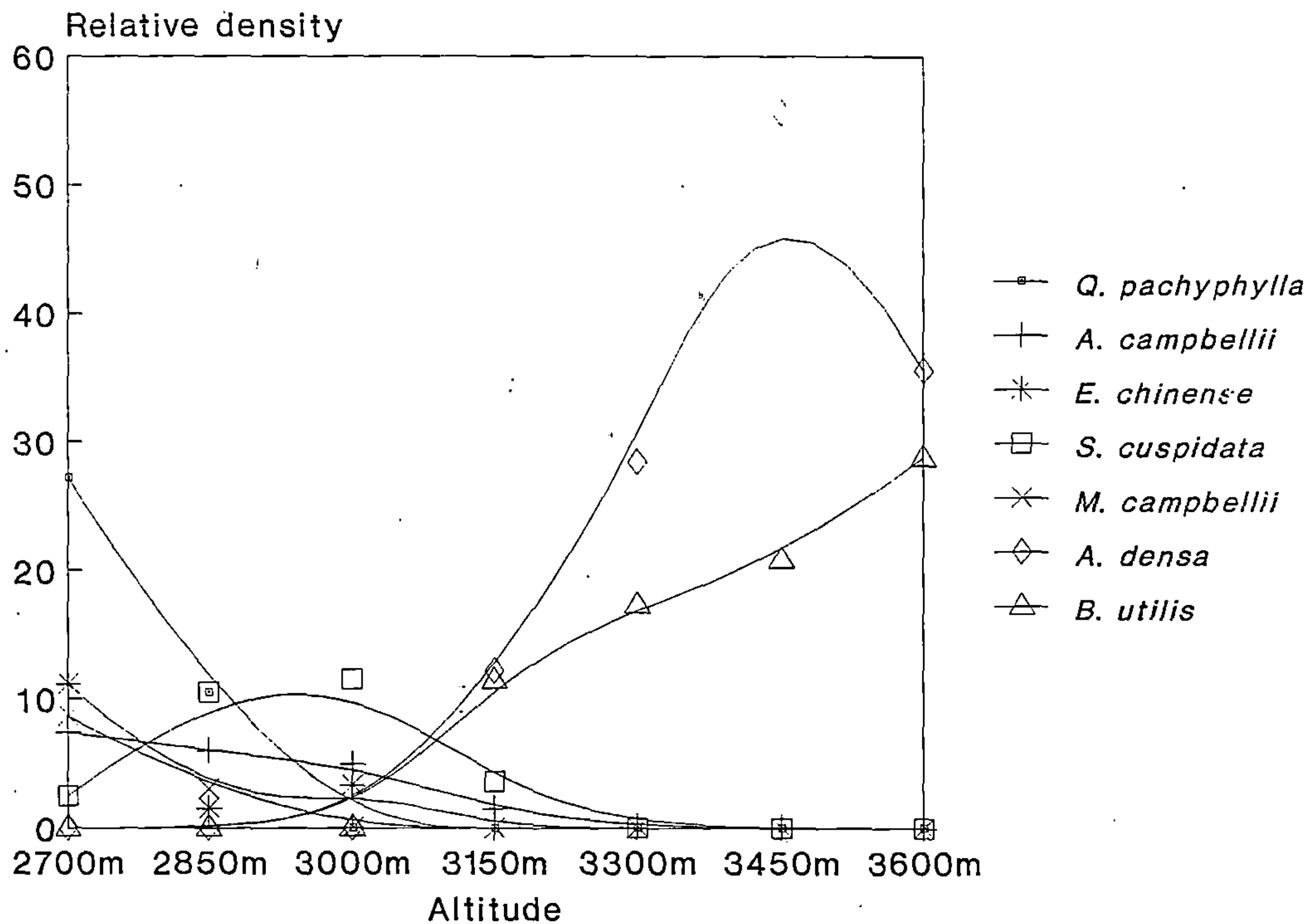


Fig.3.6 Distribution of dominant tree species in study area

Table 3.2 Density, diversity and species richness of tree species at seven altitudes of the study area.

Altitude	2700m	2850m	3000m	3150m	3300m	3450m	3600m
Density/ha	729.00	558.67	406.67	483.33	375.00	274.00	262.5
Species richness	3.73	3.61	3.00	3.94	2.18	1.08	1.24
Species diversity	1.11	1.06	0.97	1.16	0.18	0.55	0.61

Table 3.3 Seedling, Sapling and density of tree species/ha in different size classes in seven altitudes of the study area.

Altitude	Seedling	Sapling 1	Sapling 2	>31.5-70 cm	>70-150 cm	>150 cm
2700 m	2129.62	789.0	416.66	370.83	137.49	12.49
2850 m	1418.00	296.29	518.5	200.00	19.99	20.00
3000 m	1975.31	740.00	123.30	226.66	90.00	09.95
3150 m	4222.22	444.44	888.88	320.00	44.83	16.67
3300 m	6767.67	1616.1	1666.6	186.36	77.26	04.55
3450 m	5555.55	1720.4	1612.9	93.55	82.25	16.13
3600 m	14768.5	555.55	740.74	108.33	47.50	06.25

Seedling = < 30 cm height

Sapling 1 = > 30 cm height - < 1m height

Sapling 2 = < 31.5 cm girth at breast height, >1m height *cuspidata* saplings were found to be absent although represented in the seedling stage at 2850 m and 3000 m. However, *Rhododendron falconeri* which forms an important component of the vegetation in the Broad-leafed deciduous forest, was found to be represented well both in the seedling and in the sapling stages. *Betula utilis* is better represented in the sapling stage than in the seedling stage in the subalpine zone. However, sapling of *Betula utilis* was absent at 3150 m. *Abies densa* was found to have a comparatively better regeneration with it being well represented both in the seedling and sapling stages in all the altitudinal gradients of its distribution.

3.4.3 Shrubs: *Viburnum* and *Daphne* spp. are the most widely distributed shrub species which are present at six altitudes out of seven that were sampled. *Rosa sericera* and *Berberis aristata* are present above 3000 m with their highest density at 3600 m. These shrubs are known to be associated with dry disturbed sites (Shrestha, 1988). Shrubs such as *Piptanthus nepalensis, Elsholtzia fruticosa, Sambacus* sp. were found in patches in certain areas of the study area (Table 3.5).

3.4.4 Bamboo: *Arundinaria maling* and *A.aristata* are the two most dominant bamboo species present in the study area. *A.maling* is found upto an altitude of 3100m and *A.aristata* distribution ranges from 2850 m-3600 m. An increase of bamboo density with increasing altitude was indicated (Figure 3.9) by the linear regression performed on bamboo density against altitude ($r= 0.219$, $p=.001$). Evidence of bamboo grazed by yaks and cattle was found in all the altitudes that were sampled. The difference in the percent of grazed bamboo was statistically

Table 3.4 Seedling, sapling densities of few important tree species at different altitude zones in the study area.

Zone	Tree species	Seedling	Sapling 1	Sapling 2
OF	*Quercus Pachyphylla*	153.25	370.37	0
	Acer campbellii	205.33	0	24.68
	Magnolia campbellii	0	0	23.14
	Litsaea elongata	787.00	231.48	185.19
BLDF	*Sorbus cuspidata*	4.07	0	0
	Schefflera impressa	60.18	23.15	46.30
	Symplocos sp.	437.98	143.88	30.86
SAF	*Abies densa*	907.00	241.80	128.75
	Betula utilis	155.22	176.82	194.55

OF = Oak forest (2600 m-2800 m)

BLDF= Broad-leaf deciduous Forest (>2800 m-3100 m)

SAF= Subalpine forest (>3150 m-3600 m)

Table 3.5 Density/ha of shrub species at different altitude gradients of the study area

Species	2700m	2850m	3000m	3150m	3300m	3450m	3600m
Viburnum erubescense	487	1851	2098	1888	252	71	0
Daphne cannabina	185	1407	6172	2481	202	716	0
Berberis wallichii	462	2296	3333	18518	0	0	0
Rosa sericera	0	0	246	518	707	788	1851
Piptanthus nepalensis	342	0	0	74	0	0	0
Cotoneaster microphylla	0	0	0	34	101	0	0
Berberis aristata	0	0	0	74	0	0	1574
Berberis angulosa	0	0	0	148	0	0	0
Eltzostia sp.	0	0	123	148	0	0	0
Rhododendron campanulatum	0	0	0	0	0	0	2731
Rhododendron lepidotum	0	0	0	0	151	0	0

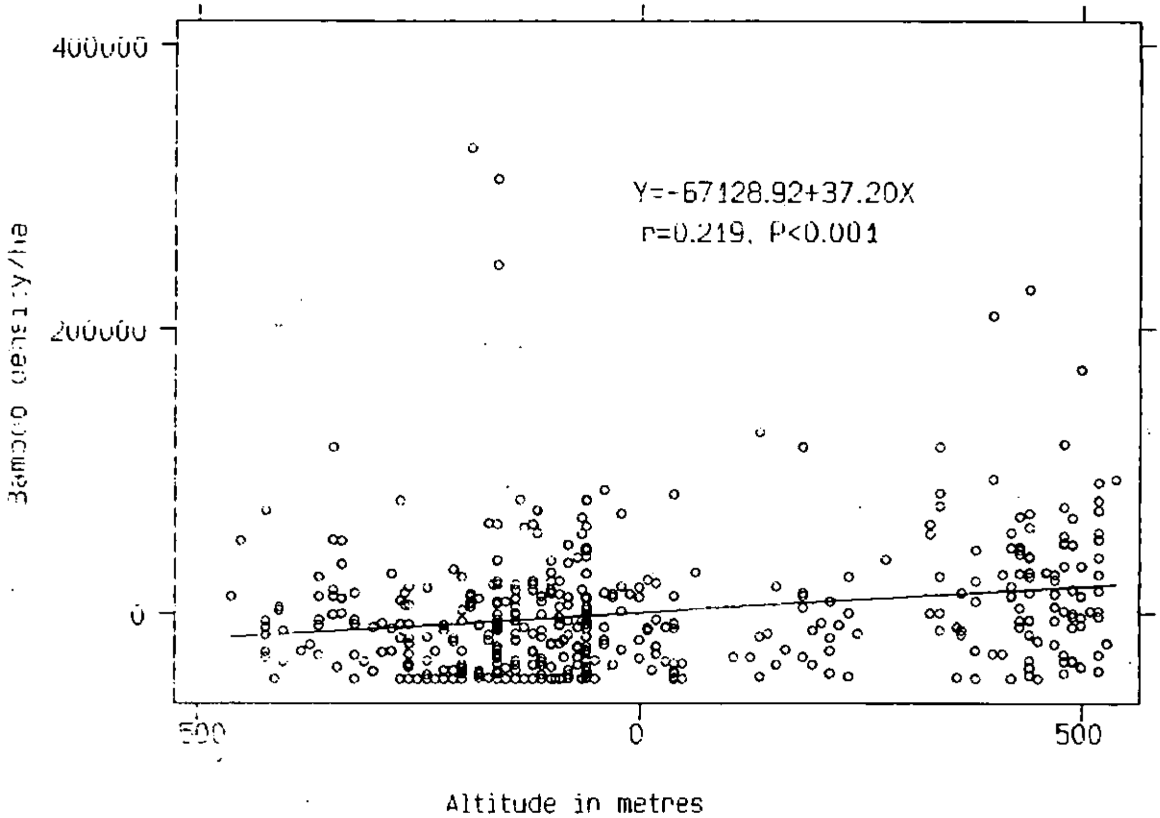


Fig.3.9 Relationship between bamboo density and altitude

significant with the percent being higher in the higher altitudes, or the subalpine zone (Kruskal Wallis, $\chi^2 = 29.32$, df=6, $p < .001$).

3.4.5 Disturbance: The vegetation of the study area and the habitat of red panda has been disturbed by several factors such as grazing, logging, lopping, construction of roads, paths, settlements, fire, landslips erosions and extraction of minor forest products. Details of disturbance factors are presented in Table 3.6. Damage from livestock as a result of grazing is not only the factor, but cowpaths or narrow trails made due to frequent use of the areas by cattle, also contribute to the damage by trampling and compacting of the soil (Shrestha, 1988). The presence of cowpath was high at 3600 m, ($\bar{x} = 1.98$), 3450 ($\bar{x} = 2.06$), and medium at 3000 m ($\bar{x} = 1.5$) and 3150 m ($\bar{x} = 1.53$). A Kruskal Wallis analysis, to test the difference in the cattle paths in different altitudes was statistically significant ($\chi^2 = 27.00$, df = 6, $p < .001$). Cattle paths are higher in the subalpine zone and were found to be positively correlated to density of percent of grazed bamboo ($r_s = 0.515$, $p < .05$). Cattle paths showed a positive correlation with the density of seedling and sapling though not statistically significant (seedling, $r_s = 0.023$, $P > .05$ and sapling, $r_s = 0.391$, $p < .05$). Density of cut stumps was highest at 3600 m with 525.00/ha followed by 3000 m (233.33/ha) and 3150 m (150.00/ha). Density of cut stumps was significantly correlated to 'other disturbances' ($r_s = 0.445$, $p < .001$).The variable 'other disturbances' include lopping pressure, disturbance from construction of roads, paths, settlements, fire, land slips and erosions. The highest intensity of 'other disturbances' was at 3000 m ($\bar{x} = 2.2$), 3150 m ($\bar{x} = 2.3$) and 3600 m ($\bar{x} = 2.04$).

Table 3.6 Intensity of disturbance at different altitudes of the study area

Altitude	Cattle paths	Other disturbances	Cut stumps (density/ha)	Grazed bamboo(%)
2700m	0.95	1.4	112.50	10.29
2850m	1.13	1.3	54.16	7.03
3000m	1.44	2.2	233.33	17.00
3150m	1.53	2.3	150.00	48.43
3300m	1.05	1.3	20.35	2.75
3450m	2.06	0.97	36.48	43.39
3600m	1.98	2.04	525.00	90.00

0-1.00 = low, >1.00-2.00 = medium, >2.00-3.00 = high are the rating scores for the intensity of disturbance

Table 3.7 Average density/ha of different size classes of trees in the study area

Size classes	1	2	3	4	5
Average density	5089±4837	1598.96±898	215.10±102	71.33±38.27	12.16 ±5.6

The difference tested for all altitudes was statistically significant (Kruskal Wallis, χ^2 = 19.22, df=6, $p < .05$).

3.4.6. Forest Structure: Details of tree densities of different size classes used to describe the structure of the forest are presented in Tables 3.8, 3.9, 3.10, 3.11, 3.12, 3.13 and 3.14. Results in table 3.7 show that the size class 1 (seedling) had the highest average density followed by size class 2 (sapling I and ii), size class 3 (>31-70 cm gbh), size class 4 (> 70 - 150 cm gbh) and size class 5 (> 150 cm gbh).

The pattern of gradual decrease of density from size class 1 to size class 5, was found in all the altitudes. It is assumed that the size class or the gbh represent the age or maturity of the tree species keeping in view the maximum gbh attained by a tree species naturally. Undercanopy trees or younger trees of uppercanopy are usually represented by size class 3. At 2700 m, *Litsaea elongata* and *R. arboreum* which are important undercanopy species had a high density in size class 3. Among the intermediate class (size class 4), *Quercus pachyphylla* had the highest density (Table 3.8).

At 2800 m, the dominant uppercanopy species, *Sorbus cuspidata,* is only represented in size class 5 (i.e. mature trees). *Quercus pachyphylla*, another uppercanopy species is almost equally represented in all the size classes. But the undercanopy species, *Symplocos* sp. has the highest density. This high density of *Symplocos* sp. is contributed mainly by its density in size class 3 (Table 3.9).

Table 3.8 Density/ha of tree species in different size classes at 2700 m.

Tree species	Size class 3	Size class 4	Size class 5
Quercus sp	12.5	70.8	12.5
Endospermum chinese	33.33	25.00	0
Acer campbellii	8.3	0	0
Magnolia campbellii	25.00	4.17	0
Schefflera impresa	29.17	29.17	4.17
Litsaea elongata	54.17	37.33	4.17
Rhododendron arboreum	125.00	29.17	0

Table 3.9 Density/ha of tree species in different size classes at 2800 m

Tree species	Size class 3	Size class 4	Size class 5
Quercus pachyphylla	13.33	13.33	20.00
Sorbus cuspidata	0	6.67	26.67
Acer campbellii	13.33	20.00	6.67
Rhododendron falconeri	6.67	6.67	0
Symplocos sp.	120.00	0	0

Table 3.10 Density /ha of tree species in different size classes at 3000 m

Tree species	Size class 3	Size class 4	Size class 5
Sorbus cuspidata	0	20.00	13.33
Acer campbellii	6.67	13.33	0
Symplocus sp.	166.7	26.67	0
Rhododendron falconeri	40.00	13.33	0

Table 3.11 Density/ha of some of the tree species in different size classes at 3150 m

Tree species	Size class 3	Size class 4	Size class 5
Abies densa	26.67	33.33	13.33
Betula utilis	46.67	6.67	0
Rhododendron arboreum	63.33	6.67	0
Sorbus cuspidata	3.33	6.67	3.33

Table 3.12 Density/ha of tree species in different size classes at 3300 m

Tree species	Size class 3	Size class 4	Size class 5
Abies densa	50.00	59.09	4.55
Betula utilis	72.73	27.27	0
Rhododendron arboreum	27.27	4.55	4.55
Tsuga brunoniana	9.09	9.09	0

Table 3.13 Density/ha of tree species in different size classes at 3450 m

Tree species	Size class 3	Size class 4	Size class 5
Abies densa	38.70	103.13	62.50
Betula utilis	19.35	25.81	0
Rhododendron arboreum	3.23	9.67	0
Rhododendron campanulatum	6.45	0	0

Table 3.14 Density/ha of tree species in different size classes at 3600 m

Tree species	Size class 3	Size class 4	Size class 5
Abies densa	37.50	66.67	4.17
Betula utilis	12.5	29.17	8.33
Rhododendron campanulatum	41.67	0	0

At 3000 m, the highest density is again, in size class 3 and the species having this high density is *Symplocos* sp. *Sorbus cuspidata* is represented in size class 4 and 5, but not in size class 3 (Table 3.10).

3150 m, has a high average density of 320 trees/ha in size class 3 (Table 3.3). Tree species like *Betula utilis, Rhododendron arboreum, R. cinnabarium* and *Abies densa* contributes to this density of 320/ha in size class 3. The only tree species represented in size class 5 are *A. densa* and *Sorbus cuspidata* (Table 3.11).

Details of density of tree species in different size classes at 3300 m are presented in Table 3.12 *Abies densa* is present in all size classes. It can be seen that the maximum density of *A. densa* in size class 5 or mature trees, were at 3450 m (Table 3.13). At 3600 m, *Abies densa* and *Betula utilis* are mostly represented in size class 3 and 4. *Rhododendron campanulatum* which forms the understorey has a density of 41.67 in size class 3 (Table 3.14).

3.4.7 Phenology: Foliation of buds and flushing of leaves started by the end of March (Figure 3.7,a). Until the beginning of foliation, leaf buds remained dormant. By June, a peak of leaf flushing was reached by which 88% of the tree species had young leaves (Figure 3.8,a). Evergreen tree species like the *Quercus pachyphylla, Daphniphyllum himalayense, Schefflera impressa, Symplocos* sp., leaf buds appeared and young leaves flushed by June, replacing the old ones. By the end of July, the leaves changed colour, texture and could be called mature leaves. From

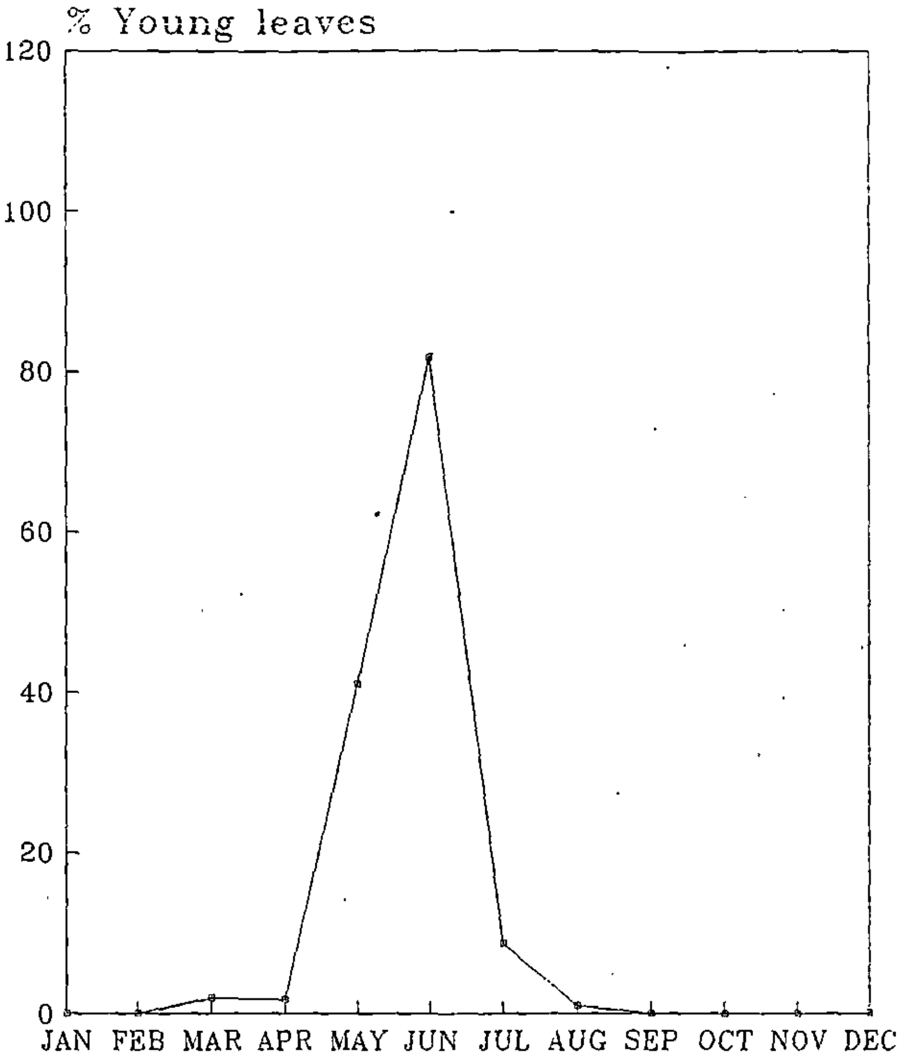


Fig.3.7a Phenological cycle showing the peak of flushing.

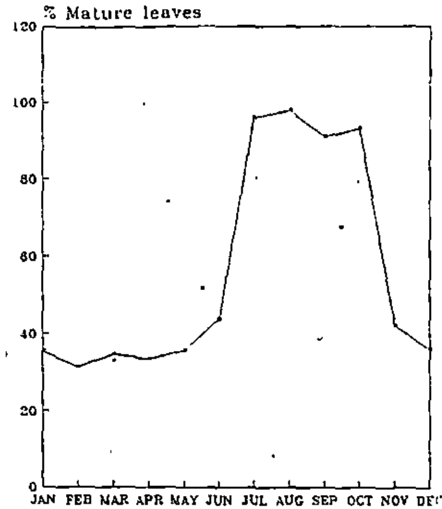


Fig.3.7b Phenological cycle showing the peak of mature leaf production

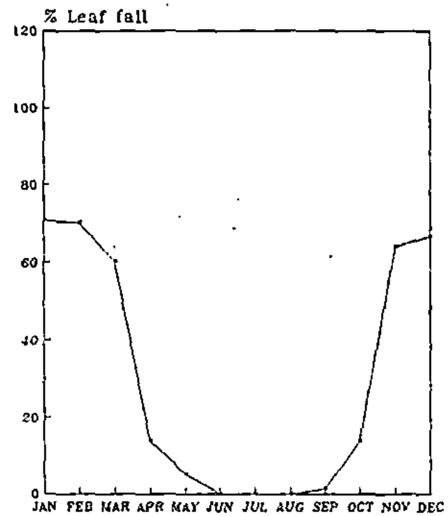


Fig.3.7c Phenological cycle showing the peak of leaf abscission

July to September, a peak in vegetative cover was reached (Figure 3.7,b) when almost all the species had mature leaves (Figure 3.8,b).

The peak of leaf abscission was attained in winter (Figure 3.7,c) when all the eleven deciduous species studied had shed their leaves and remained denuded until the time, the leaf buds started foliating again. Leaf started falling from mid-October when 16.67% of the tree species shed their leaves.

Flowering started from March. *Magnolia campbellii* flowered between April to May. *Rhododendron* spp. flowered in batches, in different months starting from March till late May. *Rhododendron* spp. and *Magnolilia campbellii* are the conspicuous flowering tree species in the Park. Peak of flowering was in May when 32% of the species were found to flower (Figure 3.8, c).

Fruits appeared by June, reaching maximum production in August-October with 48% of the species fruiting in August and September and 35% fruiting in October (Figure 3.8,d). *Osmanthus* sp. flowered in June and its fruits remained till late December. A saprophytic tree species locally known as Lahare tenga also had fruits from October to early March.

Among the shrubs and creepers, *Daphne* sp. started flowering from mid February. Others like *Berberis, Rosa, Piptanthus, Viburnum* species had flowers by May and fruits were produced from July to August. However, *Berberis* and *Rosa* species in the higher altitudes were seen to flower almost a month late- by June-July and bore fruits

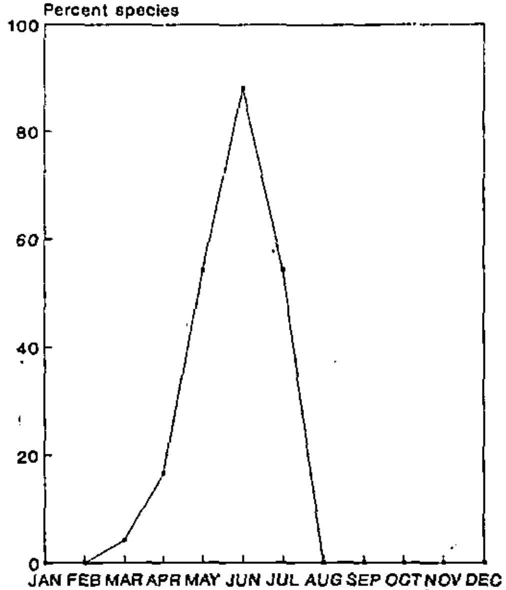


Fig.3.8a Percent species with young leaves

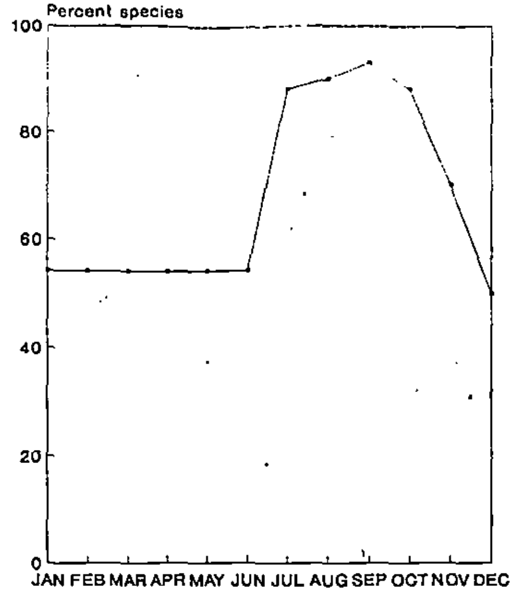


Fig.3.8b Percent species with mature leaves

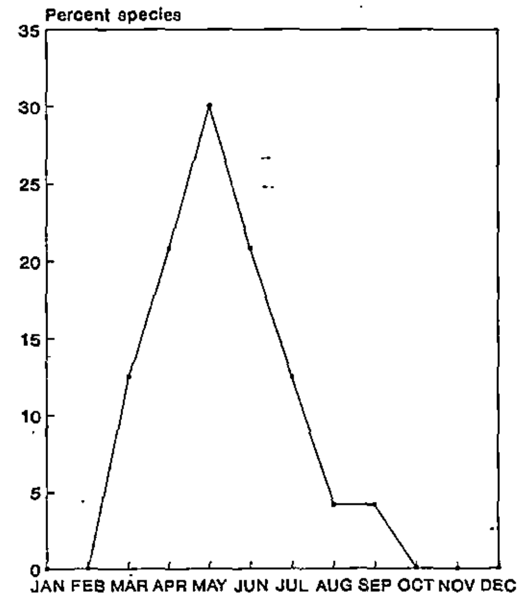


Fig.3.8c Percent species flowering

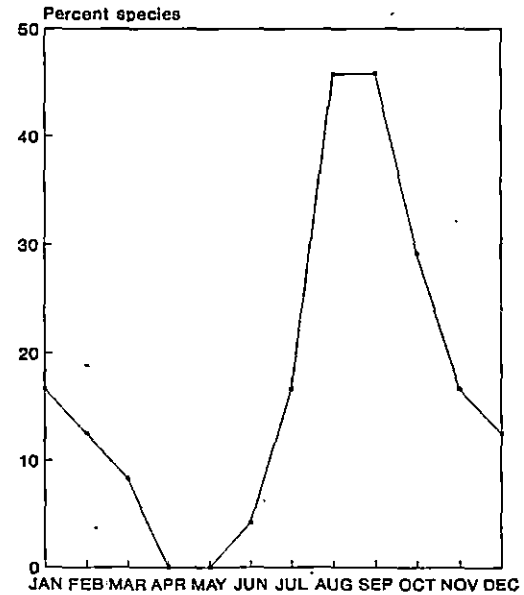


Fig.3.8d Percent species fruiting

from August. *Holboellia latifolia* and *Actinidia strigosa* were important creepers bearing edible fruits. These creepers were seen to flower from July and fruit from August to November. Leaf abscission in almost all the shrub species started from November and remained bare till April.

3.5 Discussion

The changes that are brought about in the vegetation of an area by biotic interference, management and succession would influence the habitat and thus the distribution and abundance of the animal. Placing current ecological data in their correct time context is an important aspect of ecological studies. The natural vegetation of Singhalila National Park was used and misused in the past. Hence, it was attempted to get an overview of the status of the vegetation at present.

3.5.1 Classification: The cluster analysis produced four distinct clusters of vegetation communities corresponding to the vegetation communities in altitude zones. The vegetation types are Oak forest (2700 m-2800 m), Broad-leafed deciduous forest (>2800 m-3100 m), Broad-leafed coniferous forest (>3100 m-3300 m) and the Coniferous forest (>3300 m-3450 m). This classification is followed in the thesis to explain some of the aspects of ecology of the red panda in the study area.

3.5.2 Functional spectrum of the forest: Food and cover are the two important functions that a habitat should be able to provide to the wild animals. The phenological study was incorporated here with the intention to procure some information on the availability of food and cover to the red panda in different times of the year. A general trend of phenological events in the vegetation of the study area showed that leaf flushing reached its peak during the rainy season when the area had maximum vegetative cover. Monsoon was also the season during which bamboo shoots came up along with a large varieties of mushrooms. Both, bamboo shoots as well as mushrooms serve as important food items for red panda and other animals. Mushroom was found to be taken by the red panda in the Lantang National Park, Nepal (Yonzon, 1989). Leaf fall started from October or postmonsoon season and the area had the least cover during the cold months of winter until the time leaf flushing started during premonsoon again. Bamboo forms the major understorey in the entire park and being a perennial grass, bamboo provide cover and food to the red panda and other animals throughout the year.

Peak of flowering both of the trees and the shrubs is reached during the premonsoon season and that of fruiting during the postmonsoon season during which maximum food resource in form of fruits was available in the forest. The period during which the forest has maximum cover and food coincides with red panda's birth, lactating and weaning periods.

3.5.3 Structure and Composition of the forest: Disturbance in biological balance are often recognised by changes in the physiognomy, structure and species composition of the vegetation (Dombois-Muller and Ellenberg, 1974). The present study has been able to show the distribution, abundance, dominance and regeneration status of the plant species, found to be important to the red panda habitat.

The Importance Value Index has given an overall importance of a tree species in terms of its density, total area covered and frequency of its occurrence. Data on the densities of trees in different size classes has revealed the status of individual species as well as the structure and composition of the forest. For example, the average density of tree species at 2700 m is 729/ha, but it is important to know as to which species, in which size or age group, and in what proportion is contributing to this overall density. These information are generated from the results of the densities in the five size classes studied. Some of the dominant uppercanopy trees such as the *Quercus pachyphylla, Abies densa, Sorbus cuspidata, Betula utilis, Magnolia campbellii* are important to the red panda in terms of providing refuge and cover.

S. cuspidata is also an important fruiting tree. Although the fruits of *S. cuspidata* was not found to be taken by red panda during this study, Yonzon and Hunter(1989) reported the fruit of *S. cuspidata* to be one of the important food items of the red panda. In the present study, *S. cuspidata* was found to be distributed from 2700 m to 3150 m but abundant at 2800 m-3000 m. The data on the density of trees species in different age classes revealed that *S. cuspidata* was represented only in seedling class, size class 4 (intermediate) and size class 5 (mature) whereas its representation in sapling class and size class 3 was nil. It may be recalled here that the size classes are based on the gbh of trees (refer section 3.4.6 of this chapter) and it is assumed that the increasing size classes represent the increasing age or maturity of a tree species. Absence of the species in size class 3 (immature stage) is therefore an indication of the absence of young or immature *S. cuspidata* trees. The absence of saplings of *S. cuspidata*, indicates a recruitment pattern which, according to Bargali *et al.* (1989), is of a population which reproduced in the past but at present proper establishment of saplings are not favoured, although seedlings are coming up. Absence or very low representation of the species in sapling stage indicates an interruption in regeneration (Bargali, *et al.* 1989). Such interruptions in regeneration of a species could be due to any factor of environmental disturbance to the species. *S. cuspidata* fruits are collected in large amounts by the people which could be a source of disturbance to the regeneration of the species. This fruit is used for adding flavour to the local liquor that is brewed. Recruitment of *Magnolia campbellii* was also found to be very poor with no representation in seedling class which indicates that the species is reproducing infrequently (Knight, 1975). It is thus important for the managers to give special protection and artificial regeneration priorities to *S. cuspidata* and *Magnolia campbellii.* In case of *Quercus pachyphylla,* representation was low in sapling II (<31.5 gbh, >1 m height) and size class 3. This also indicates interruption or disturbance to its proper establishment. *Betula utilis,* mostly forms the undercanopy but at places also forms the uppercanopy also. Taylor *et al.* (1991) found *Betula* spp. to colonise clear-cuts more rapidly than conifers. They reported that stands of conifers which had been clear cut, to be now solely composed of the opportunistic species of *Betula* during their study of habitat restoration of the giant panda after the flowering and death of bamboo in Wolong Nature Reserve. Loss of a dominant conifer component in these habitats of the pandas could be detrimental to the giant pandas and red pandas as they both use hollows, over-mature conifers as maternity dens (Schaller et al., 1985; Taylor and Qin, 1989). *Betula utilis,* during the present study was found to be well represented in immature and intermediate classes but has low representation in seedling class, a case similar to that of *Magnolia* *campbellii.* Contrary to the general and local belief, that *Abies densa* is in danger of being extinct in the area, it was found that the species had a better reproduction and establishment status as indicated by the density of the species in all the size classes. However, it is important to note that *A. densa* is a slow growing species which attains an average diameter of 9 inches in sixty years (Anon, 1967). Disturbance from factors such as cattle paths, grazing, felling are seen to be prevalent at all altitudes with their intensity highest at 3000 m, 3600 m and 3150 m. The higher disturbances at 3000 m, 3150 m and 3600 m is because of the presence of disturbance not only from cattle paths, grazing and lopping but from other disturbances such as construction of roads and presence of settlements. 3000 m roughly make the altitudinal limit of Gairibans and Kalipokhari and this contour is represented by ridge which is usually open and denuded. 3600 m is also the altitudinal limit of Sandakphu. A road runs along this contour which is constantly used. Apart from these, a number of trekker huts and government quarters are present at 3600 m (Sandakphu) which contributes to the biotic pressures in this altitude. Sandakphu, although has very low human population, the area receives a large number of tourists. The area being in the highest altitude is also colder than other areas. These factors increase the use of fire wood consumption and would explain the high density of cut stumps recorded in this altitude, thus effecting the intactness of the red panda habitat in the area. The disturbance in the higher altutudes have been mainly occurred due to the higher number of cattle stations in these altitudes. The sapling densities and the relatively high densities of the seedlings could imply that the tree species in the study area are now regenerating. Bamboo, one of the most important component of red panda habitat, is extensively grazed and trampled upon and more so in the subalpine region. Past records of the quantitative analysis of vegetation of the National Park for comparison is scarce. The results presented here can be used for future reference to evaluate the future changes in the vegetation. The low density of dominant trees in immature class, indicates an interruption and disturbance in their establishment. Although the overall high density of seedlings indicate recovery after the disturbance to the vegetation of the area, it is important to give specific attention and conduct long term monitorings of the recruitment dynamics of the vegetation in the National Park. The area needs complete protection and judicious management inputs. This is important in order to provide an intact habitat to the red panda and other wildlife species in the area.

The present study is a conventional method of resource survey, as compared to the latest technology of remote sensing using satellite data for forest and land use mapping. Sudhakar *et al.* (1993) opine that the conventional method suffer from various constraints such as inadequate trained manpower, lack of infrastuctural facilities, inaccessibility of remote and difficult terrain and non-availability of real time data which render the information inflow back-dated and incomplete. Sudhakar *et al.* (1993) however, also points out the disadvantages of the digital data which is not able to consider variables like texture, pattern, association and location. The technology would also be ignorant of the detailed recruitment data of critical species important to a habitat although they do have the facilities of repetitive monitoring of forest cover changes. In an area as the present one, where there has been no prior scientific investigations, this study has the importance of providing data which could be used as a reference for future monitorings of the red panda habitat, either using the conventional methods or the technology of remote sensing.