CHAPTER 6

CASE STUDY II

6.1. BHUTAN AND ITS FOREST

The Kingdom of Bhutan nestles in the folds of the Eastern Himalayas between 88° 45' and 92° 10' longitude east and 26° 40' and 28° 15' latitude north. Sandwiched between the Chinese state of Tibet in the north and Indian states of West Bengal and Assam in the south, and Arunachal Pradesh in the east, it is a small landlocked country. It covers an area of approximately 46,500 km_, roughly the size of Switzerland. The topography is very rugged, ascending from 100 m above sea level in the south to 7550 m in the north. Indeed, due to its location on the junction of two major biogeographical realms – the temperate Palearctic and the tropical Indo-Malayan – and extreme variation in climate and altitude, Bhutan harbours an astounding array of flora and fauna; some 5000 species of vascular plants, as many as 750 endemic to the Eastern Himalayas and more than 50 to Bhutan itself, more than 100 species of mammal and more than 640 bird species. Bhutan, therefore, has been listed as one of the 10 hotspots for biodiversity on the globe (RGoB, 1996).

Forests in Bhutan represent the major natural resource corresponding to 72.5 % of the total land area (Fig. 6.1), of which 30-40% (i.e. 26% of the total land area) has been declared as protected and set-aside for conservation (Anon, 1998). This is a noteworthy effort on the part of the Royal Government of Bhutan, given the global standard set for each country being only 12% (Gyamtsho, 1998). Bhutan's largely intact forest is also admired internationally.

Economically, forests in Bhutan play a significant role both nationally and locally. About 11% of the country's Gross Domestic Product (GDP) comes from forestry and generates 3% of government revenue through royalty collection and sales of wood and wood products. Timber and other wood products account for 20% of exports. Forest is also one of the main resources for runoff river sustainability for the generation of hydro-electricity, which at present is the highest revenue earner in the country. Forests also provide wood, fodder, fuelwood, leaf-litter and non-wood forest products for 80% of the population.

Ecologically, safeguarding a large proportion of forest resources is important for the country's fragile watersheds, which are vulnerable to the instability of land in the folds of young and growing Himalayan ranges. Realizing this, the Royal Government has assigned a high priority to the ecological functions of the forest and adopted a policy of maintaining 60% of the land under forest at all times (RGoB, 1996).

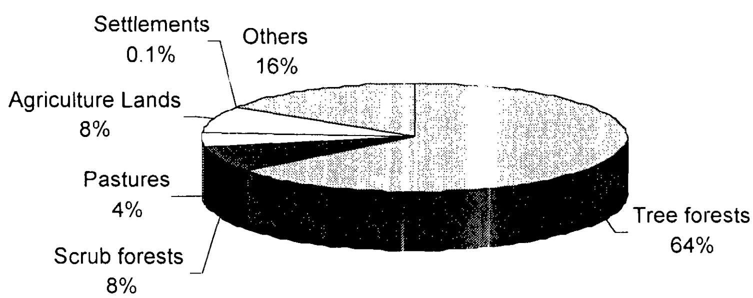
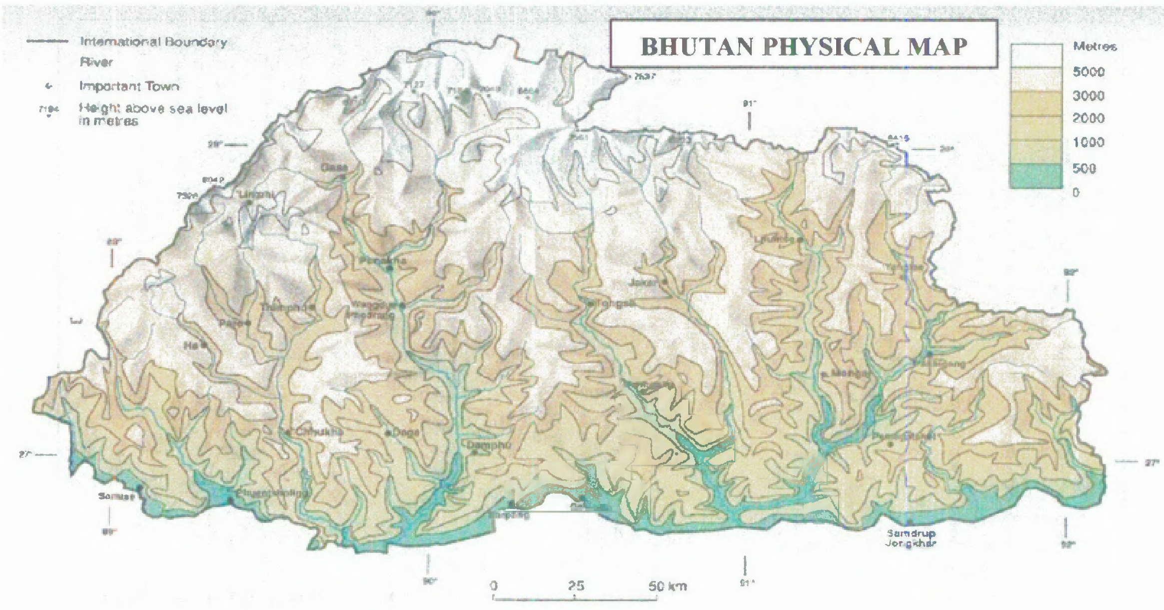


Fig. 6. 1. Land cover in Bhutan (LUPP, 1995)

6.2. MAJOR VEGETATION ZONES

The country's great variation in altitude and topography (Fig. 6.2.) produces a wide range of climatic conditions. The monsoon wind, which blows north from the Bay Bengal is a major factor influencing the climate. This brings heavy rainfall to the foothills and to the exposed slopes and valleys further north during the monsoon season, from June to September. However, several main valleys remain dry or receive very little rain during the monsoon. As a result, there is a wide variation in the growth rate of trees and other vegetation, depending on altitude and topography. Thus, many have proposed dividing the country's vegetation into various types, based on altitude and the presence of dominant tree species (GoI, 1981; Negi, 1983; Grierson & Long, 1983; Ohsawa, 1987). Six major vegetation zones were recommended by Ohsawa (1987) corresponding to the six climatic zones- Tropical (100-1000 m), Subtropical (1000-2000 m), Warm Temperate (2000-2500 m), Cool Temperate (2500-3000 m), Sub-alpine (3000-4000 m) and Alpine (>4000 m).

The temperate zone falling between 2000 m to 3000 m has conifer/broad leaf type of forests. The alpine zone (4000 m and above) has no forest cover, and the sub-tropical zone with tropical/subtropical vegetation from an elevation of 1500 m to 2000 m. Forest types include subtropical, broadleaf, chir pine, blue pine, and upland hardwood forest.



6.3. AVIFAUNA OF BHUTAN

The ornithological field in Bhutan is still in its infancy. In early 1930, Ludow pioneered Bhutan's first intensive avifaunal study (Ali *et al.*, 1996). It was not for another three decades before the next major study of the avifauna was initiated. This consisted of nine surveys conducted by Dr. Salim Ali, Dr. Biswamoy Biswas and Dr. S. Dillon Ripley. They recorded 516 species of birds from the Kingdom of Bhutan. This represents nearly 43 percent of the avifauna of the whole Indian Region. Recent visits by Inskipp *et al.* (1999) indicate that more than 616 bird species are likely to be found.

BirdLife International identified conservation hotspots known as Endemic Bird Areas throughout the world based on the distribution patterns of birds with restricted ranges. Bhutan is recognized as a part of Himalayas Endemic Bird Areas (Stattersfield *et al.*, 1998). Bhutan has a diverse avifauna. Its avifauna is internationally significant not only because it has some endemic species, but also it has a record of some globally threatened species (Inskipp *et al.*, 1999). Collar *et al.*, (1994) regarded 16 globally threatened or near-threatened species in Bhutan. Fourteen of them are listed as globally threatened by BirdLife International (Inskipp *et al.*, 1999).

The country's policy to maintain 60% of the land under forest cover for all time is not only very positive for the country's outstanding birdlife, but also reflects the enlightened conservation approach of the Royal government to both conservation of the environment and sustainable development. In Bhutan, however, this revolutionary approach to conservation is not new because wildlife has a significant role to play not only in maintaining the ecological health of forests, but it also has important symbolic functions in Bhutan's social fabric and setting. Birds in Bhutan have always been highly valued. This is evident from the incorporation of a raven into the design of the crown of the King of Bhutan 'The Raven Crown' (Fig. 6.3), the raven symbolizing the protecting deity of the country.

Fig. 6.3. The Raven Crown (Bhutan).

6.4. FOREST AND LIVESTOCK GRAZING

Bhutan has throughout history been an agricultural country and the farming systems depended heavily on forests for fodder, plant nutrients, firewood, leaf-litter and non-wood forest products to supplement household food requirement for 80% of the population. The Renewal Natural Resources (RNR) sector consisting of agriculture, livestock and forestry sub-sectors plays a dominant role in the national economy and still remains the single largest contributor to the country's Gross Domestic Product (GDP) at 36.7% in 1998 (RGoB, 1996).

Livestock is an integral part of the agricultural system, contributing about 21% of the agricultural GDP (RGoB, 1996). In the Alpine region, yaks are the dominant animals, whereas cattle are dominant in the temperate and subtropical regions and owned by 90% of the country's households (RGoB, 1996).

Livestock grazing is an age-old tradition in Bhutan and comprises two different systems - a small herd, which is usually kept near villages and settlements throughout the year, and bigger herds, which migrate seasonally between summer and winter grazing grounds. Livestock graze in forests and in a tract of forestland with or without trees belonging to the state, where people have rights to pasture their livestock for the payment of an annual fee, know as Tsamdrogs (Norbu, 2000). However, no clear distinction exists between the two and livestock indiscriminately graze in both Tsamdrogs and forest. The tradition of seasonal migration is common throughout the Himalayas and it is a strategy to derive optimum use from their pastureland by the pastoralists (Miller, 1993). This system allows each grazing ground time to regenerate before it comes into use again.

However, there is growing concern about the increasing number of livestock exerting pressure on forage resources and forest (Norbu, 2000). Dorji (1992) mentions that the current numbers of livestock far exceed the available grazing ground by about three fold. The presence of a large number of unpalatable forbs and shrubs, reduced abundance of seedlings and saplings, and a high incidence of lopping indicates that grazing land/ Tsamdrogs are deteriorating both in quality and quantity (Gibson, 1991; Norbu, 2000). The absence of a clear boundary between Tsamdrogs and adjacent forests has also raised concerns about the overgrazing of forestlands, not to mention the effects caused by trampling on soil and herb layer.

6.5. SIGNIFICANCE OF THE STUDY

In an effort to conserve the current natural resources of the nation, attempts are now made to include conservation aspects and other social functions other than wood production into forest management planning (Salter, 1995; Dhital, 1998). A recent study by Norbu (2000) highlights the importance of this holistic approach to the sound management of natural forests so that the plan takes into consideration the needs and aspirations of local people. The current National Forestry Policy focuses on conservation with particular emphasis on traditional community forest-use such as grazing. The present study looks at the bird communities in both grazed and ungrazed lands. Such a study will be important to balance conservation issues with the traditional land-use, especially in protected areas

In this study, I compare the bird communities in grazed and ungrazed habitat in two forest types – broadleaf forest at Gedu and chir pine forest at Lobesa. The present study addresses the following specific questions:

1. Are the bird assemblages of the two forest types different?

2. Are there any difference in bird assemblages in each forest type between winter and spring?
3. Are the bird assemblages of each forest type different in grazed and ungrazed sites?
4. Is there any significant difference in species diversity and abundance of birds between grazed and ungrazed sites in each forest type?
5. Is there any significant difference in the ecological guilds, between grazed and ungrazed sites in each forest type?
6. Is there a significant seasonal variation in the diversity and abundance of birds in the grazed and ungrazed sites in each forest type?

CHAPTER 7

METHODS

7.1. INTRODUCTION

Case study II was carried out in two different forest types in Bhutan – broadleaf forest and chir pine forest (referred to as pine forest hereafter). Cattle usually graze the former more extensively than the latter, perhaps due to the greater abundance of shrubs and understorey, on which the cattle usually browse. In pine forest, the understorey and shrub densities are relatively low and cattle usually graze on palatable forbs and grass. In my two study areas, the density of cattle in the grazed habitat in pine is lower than the density of cattle in grazed habitat in broadleaf. Generally, the farmers in broadleaf forests can be grouped as seasonal migratory herders or sedentary farmers, who remain in the same place throughout the year. The former live in the study area from November to March and migrate to higher areas (summer grazing) from April to October, whereas the farmers in the pine forest study areas are usually sedentary herders with comparatively fewer cattle. The distance between the two study sites is about 150 km.

This chapter briefly describes the study area in pine and broadleaf forests respectively, with reference to their location, climate, and habitat description, followed by bird survey, habitat measurement and data analyses. Bird survey techniques and data analyses were similar to those described in Chapter 3, and only the main differences in methods and data analyses are mentioned in this chapter.

7.2. LOCATION

The study area in pine forest was located in and around the campus of NRTI (Natural Resources Training Institute) at Lobesa at an elevation of 1440 m above sea level, facing north-east. Though it is close to Wangdiphodrang district, it has been recently included under Thimphu district. The study area in broadleaf forest was located at Gedu in Chukha district between elevations of 1800 m to 2300 m. The two districts are among the 20 administrative units in the country and lie in the western and southern part of Bhutan respectively. There is little existing information about the forest in the two study areas at Lobesa and Gedu (Fig. 7.1.).

In the pine forest, the sample points were chosen in and around the campus of NRTI (Natural Resources Training Institute) at Lobesa. The campus encompasses a gross area of about 12 ha and has sites that have been excluded from grazing for more than 5 years. The boundary of the campus merges with surrounding pine forest, which is grazed by cattle from the nearby settlement The topography ranges from flat to very steep slopes. A total of 60 sampling points were established, with 30 sampling points in ungrazed plots in the campus (Fig. 7.2) and 30 in grazed sites outside the campus in the nearby forest (Fig. 7.3).

At Gedu, the sampling points in the broadleaf forest were chosen in the plantation area near the Forest Checkpost (Fig. 7.4) and the other at Bunorsasungsa (Fig. 7.5). The plantation area has been excluded from livestock grazing for at least 10 years and the Bunorsasungsa area has been grazed for more than 20 years. A total of 60 sampling points with 30 each in the plantation area and Bunorsasungsa were randomly chosen.

In both forest types, the sampling points were at least 200 m away from each other to avoid recording the same birds again in the neighbouring sample points. In both forest types, the ungrazed area was not completely excluded from grazing. Light grazing was still prevalent in the sites that have been treated as ungrazed, but this is of much lower intensity than the grazed sites. In addition, the extent of grazing and density of cattle in pine forests is less than in broadleaf forest. Overall, cattle graze in the two forest types in and around the study areas and it is hard to find areas untouched by cattle.

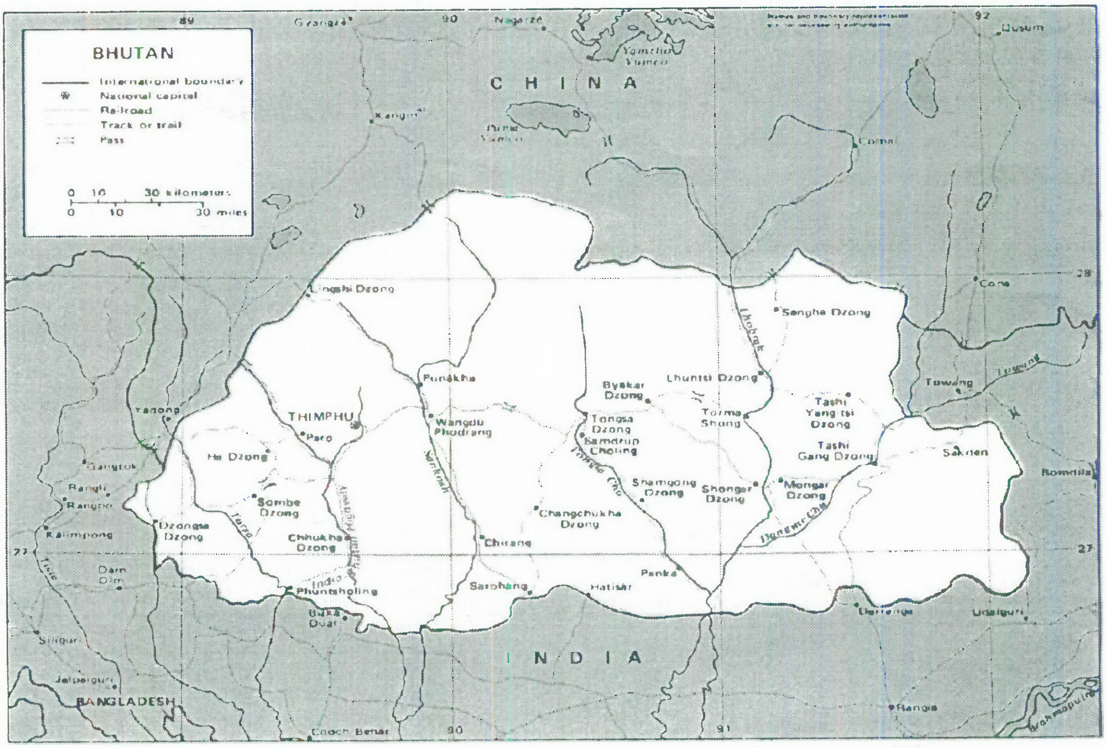


Fig. 7.2. Ungrazed site in pine forest in the NRTI (Natural Resources Training Institute) campus at Lobesa, Bhutan.

Fig. 7.3. Grazed site in pine forest near NRTI (Natural Resources Training Institute) at Lobesa, Bhutan.

Fig. 7.4. Ungrazed site in broadleaf forest near Forest Checkpost at Gedu, Bhutan.

Fig. 7.5. Grazed site in broadleaf forest at Burorsasungsa at Gedu, Bhutan.

7.3. CLIMATE

Generally, the study area in pine forest is temperate, with cool or cold winters, hot summers, and with moderate rainfall. Lobesa experiences dry winter months (December-February) and almost no precipitation until March, after which rainfall increases steadily. The lowest monthly average temperature recorded was 13.8 °C in January 2002 and highest at 27.8 °C in June 2002 with a relative humidity of 65.48 %. The average monthly temperatures in Lobesa from July 2001 to June 2002 are presented in Fig.7.6. Monthly measurement of rainfall from July 2001 to June 2002 is given in Fig. 7.7.

The study area in broadleaf forest in Gedu is subtropical with long, humid and wet summers, and short, dry winters. The average monthly maximum and minimum temperatures from July 2001 to June 2002 are presented in Fig. 7.8. Monthly maximum temperature was 26.5°C in August 2001 and monthly minimum temperature was 4.5 °C in January 2002. Almost 80% of the precipitation falls in the monsoon season (May-September). Monthly rainfall from July 2001 to June 2002 is shown in Fig. 7.9. Average relative humidity is 88.5 %. All meteorological information for Lobesa was supplied by Govinda Sharma, Lecturer, NRTI (National Resources Training Institute) and for Gedu by Ministry of Trade and Industry via Raling Ngawang, District Forestry Officer, Thimphu.

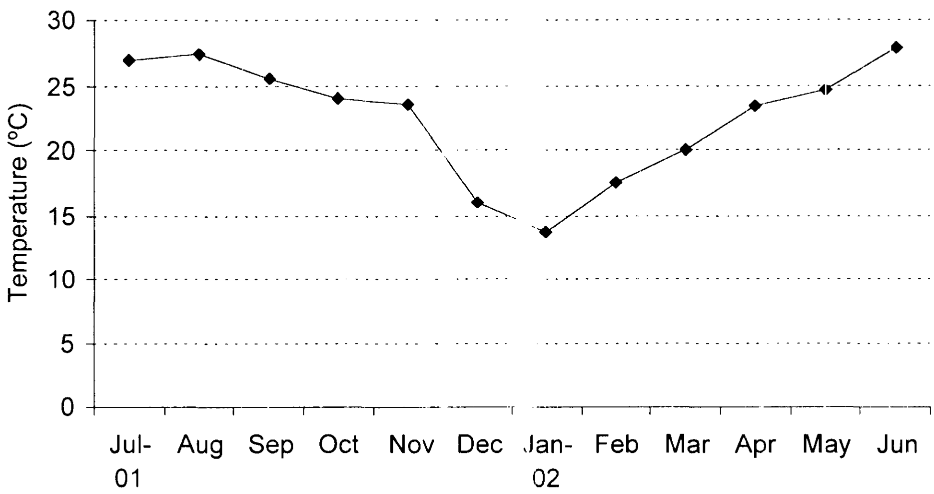


Fig. 7.6. Monthly average temperature (°C) at Lobesa (pine forest study area) from July 2001 to June 2002.

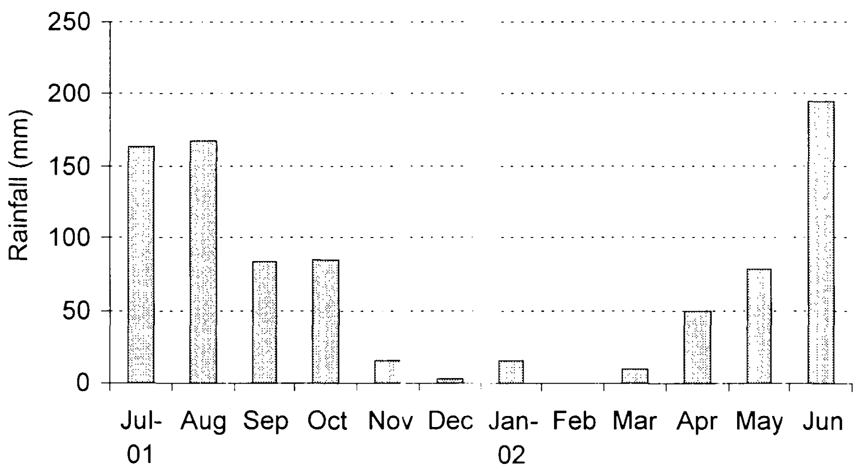


Fig. 7.7. Monthly rainfall (mm) at Lobesa (pine forest study area) from July 2001 to June 2002.

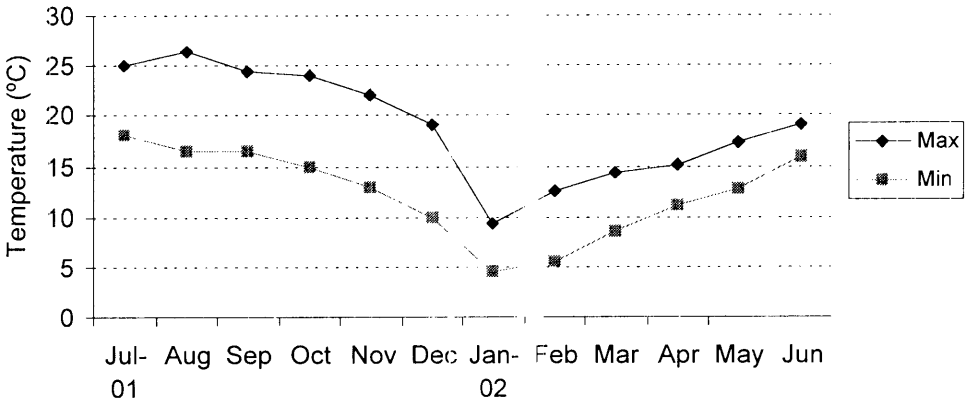


Fig. 7.8. Monthly maximum and minimum temperature (°C) at Gedu (broadleaf study area) from July 2001 to June 2002.

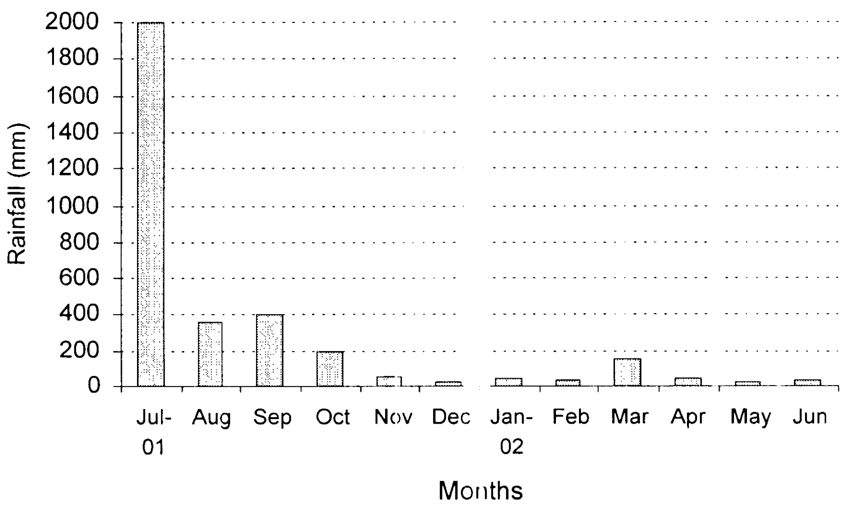


Fig. 7.9. Monthly rainfall (mm) at Gedu (broadleaf study area) from July 2001 to June 2002.

7.4. HABITAT DESCRIPTION

Chir Pine *Pinus roxburghii,* is the dominant tree in both grazed and ungrazed sites in the study area in pine forest. Generally, Chir Pine forest has almost no other tree species and a poorly developed shrub layer of *Desmodium elegans, Buddleja asiatica* and *Indigofera dosua. Rhododendron arboreum* and *Lyonia ovalifolia* forms the mid-canopy layer (Grierson & Long, 1983). Tree stands in both grazed and ungrazed plots are similar.

The study area in the Broadleaf Forest is evergreen broadleaf type and has species that fall under the subtropical and warm temperate zone. The common tree species includes *Persea clarkeana, Castanopsis hystrix, Acer campbelli, Quercus lamellosa, Ficus neriifolia, Michelia doltsopa, Beilschmiedia gammieana* and *Cinnamomum impressinervium.* The sub-canopy layer includes the following genera, which are pioneers in secondary forests near settlement: *Symplocos, Casearia, Eurya, Daphniphyllum,* and *Viburnum.* In ungrazed sites there are many stands of seedling and saplings. The grazed sites have fairly low tree stands and understorey vegetation compared with the ungrazed sites. In general, broadleaf forests have many species of birds including some of the restricted range species (Inskipp *et al.*. 1999).

7.5. BIRD SURVEY

For the sake of consistency and also for the advantages described in Chapter 3, the point counts was used to survey the birds in both the pine and broadleaf forests in Bhutan. Details of this technique have been given in Chapter 3. In the broadleaf forest, which has a thick understorey layer, there is the risk of flushing the birds away without necessarily identifying them as one traverses the plot. Point count was an effective technique in such forests as it gave the observer a chance to identify and count the birds from a point, without flushing the birds. During the census period, especially in the grazed sites in the broadleaf forest, I encountered a few wild deer. Some of the sampling points in ungrazed sites were deep in the forest with a thick understorey, accessible only to feral cattle and wild ungulates. Here the chance of encounter with the Asiatic black bear *Ursus (Selenarctos) thibetanus,* was very high, especially in early spring. Frequently, I came across herders who sighted them at distance and cautioned me to avoid sudden and direct confrontation with them.

I counted birds at a total of 120 sampling points, 60 each in each forest type, and 30 each in grazed and ungrazed sites in each of the forests. All the birds seen within 50 m and heard within 100 m were recorded at each sampling point during the period of 10 minutes. A preliminary five minutes was taken at each sampling point to allow the birds and observer to settle down. Each sampling point was visited once in winter (Dec- Feb) and spring (March- May) only in both forests. Each of the sampling points was marked on the first visit so that the following census was made at the same sampling point. Because the chances of bird detection decline from midday till mid afternoon (Bibby *et al.*, 1992), all the bird surveys were carried out in the morning from 5.30 am to 10 am. Wet, cloudy or foggy days were excluded for bird surveys to reduce any bias due to unpleasant weather condition. Birds of Bhutan (Inskipp *et al.*, 1999), was used to aid in the identification of the species. Prior to the survey, I have made several visits to other sites with similar vegetation to become familiar with different bird species. Mrs. Rebbacca Pradhan, an ecologist in Royal Society of Protection of Nature (RSPN) and Mr. Gyem Tshering, a lecturer in Natural Resources Training Institute (NRTI), helped me with the identification of some of the species.

7.6. HABITAT MEASUREMENT

In order to detect the difference in habitat structure associated with grazing and the bird community, various habitat variables were measured in both forest types. The habitat variables measured included: canopy height, proportion of grass cover, frequency of cattle tracks, percentage of understorey cover, and number of trees. These habitat variables were measured within a 25 m radius circle centered on each sampling point. Habitat measurements were taken only once, during winter.

7.7. DATA ANALYSIS

Data analyses were carried out in the same way as for the New England data. First of all, a contingency table of the presence or absence of each species was constructed and the data were analyzed using 'Chi square' to detect any apparent preference for grazed and ungrazed plots for each of the forest type. The birds were divided into three different ecological guilds – canopy birds, shrub birds and ground birds - based on observations of their behaviour and foraging activities and the knowledge of Hugh Ford from observations of the same or similar species in Malaysia and Europe. Repeated measures ANOVA was applied to overall bird species richness and abundance including the richness and abundance of each of the guilds separately to detect the effect of plots (grazed/ungrazed), season (winter/spring) and forest types (pine/broadleaf). First order interaction of plots by season was considered significant at the conventional level of significance at $p < 0.05$. Where there was a significant second order interaction (i.e. plots by season by forest type), conservative tests like Greenhome-Geisser's and Hynh-Feldt test of repeated measure factor (mean) were done. Homogeneity in the data sets was detected by Levene's test. In cases where heterogeneity was tested ($p < 0.05$), the necessary transformations were applied. All these analysis were done using MINITAB™.

Canonical Correspondence Analysis (CCA) was used to elucidate the relationships between assemblages of species and their environment. The reason for the use of such multivariate methods has been discussed in Chapter 3. Overall, 71 species were identified in broadleaf forest and 32 species in pine forest over two seasons in 30 sampling points, each in grazed and ungrazed plots. The abundance table thus contained 71 x 120 non-negative values in broadleaf forest and 32 x 120 non-negative values in pine forest and a secondary matrix of 9 environmental variables in each forest type. Canonical Correspondence Analysis was performed using the package CANOCO™ version 4.5.

CHAPTER 8

RESULTS

8.1. COMPOSITION OF BIRD ASSEMBLAGES

A total of 359 individual birds* representing 31 species occurred in the plots in the pine forest and 452 individuals representing 71 species were recorded in broadleaf forest. There is a different assemblage of birds in the two forests with only 17 species common to both forest types, indicating that the majority of species are different (Appendix 3).

A total of 183 individuals of 30 species occurred in grazed plots and 176 individuals of 25 species in ungrazed plots in pine forest (Appendices 4a & 4b). The Verditer Flycatcher was present exclusively in spring in ungrazed plots (Table 8.1). Six species occurred exclusively in grazed plots, with Pied Bushchat, Large-billed Crow and Rosy Pipit present in both seasons and the rest in spring (Table 8.1). No species was found significantly more often in either grazed or ungrazed plots.

Table 8.1. The bird species detected exclusively in either grazed or ungrazed plots in pine forest study area in Bhutan for two seasons. (+) mark indicates the presence of that species. Ecological Guild: C = Canopy; S = Shrub; G = Ground.

Species		Grazed plots		Ungrazed plots	
	Guild	Winter	Spring	Winter	Spring
Verditer Flycatcher	C	–	–	–	+
Pied Bushchat	S	+	+	–	–
Rosy Pipit	G	+	+	–	–
Little Bunting	G	–	+	–	–
Chestnut-tailed Starling	G	–	+	–	–
Large-billed Crow	G	+	+	–	–
Grey-chinned Minivet	C	–	+	–	–

* Scientific names are given in Appendix 3.

A total of 146 individuals of 36 species in grazed plots and 306 individuals of 61 species in ungrazed plots occurred in broadleaf forests (Appendices 5a & 5b). Ten species occurred exclusively in grazed plots (Table 8.2). Among them, only Grey Bushchat was recorded in both seasons. Six species were present significantly more often in the ungrazed plots (Table 8.3). In addition to this, 35 species were recorded only in ungrazed plots, with ten of them occurring in both seasons and 11 in winter and 14 in spring (Table 8.4).

Table 8.2. The bird species detected exclusively in grazed plots in broadleaf forest study area in Bhutan for two seasons. (+) indicates the presence of that species. Ecological Guild: C = Canopy; S = Shrub; G = Ground.

Species		**Grazed plots**		**Ungrazed plots**	
	Guild	Winter	Spring	Winter	Spring
Black Bulbul	C	−	+	−	--
Tickell's Leaf Warbler	C	−	+	−	--
Rufous-breasted Bush Robin	S	+	−	−	--
Grey Bushchat	S	+	+	−	--
Dark-sided Flycatcher	S	−	+	−	--
Large Niltava	S	−	+	−	--
Maroon-backed Accentor	G	+	−	−	--
Rosy Pipit	G	+	−	−	--
Long-tailed Shrike	S	−	+	−	--
Common Green Magpie	C	−	+	−	--

Table 8.3. Number of sampling points containing each species that occurred significantly more often in ungrazed plots in the broadleaf forest study area. Ecological Guild: C = Canopy; S = Shrub; G = Ground.

Birds	**Guild**	$\_^2$	**Grazed**	**Ungrazed**
Green-tailed Sunbird	C	11.52***	7	17
Green-backed Tit	C	14.06***	4	14
Whiskered Yuhina	C	3.76*	6	13
Blue-fronted Redstart	S	4.02*	5	12
Grey-hooded Warbler	S	4.812*	3	10
White-throated Laughingthrush	G	4.32*	2	8

Table 8.4. The bird species detected exclusively in ungrazed plots in broadleaf forest study area in two seasons. (_) indicates the presence of that species. Ecological Guild: C = Canopy; S = Shrub; G = Ground.

Species		Grazed plots		Ungrazed plots	
	Guild	Winter	Spring	Winter	Spring
Grey-bellied Tesia	S	–	–	–	+
Blyth's Leaf Warbler	C	–	–	+	+
Greenish Warbler	C	–	–	+	+
Yellow-browed Warbler	C	–	–	+	+
Brown-flanked Bush Warbler	C	–	–	–	+
Chestnut-crowned Warbler	C	–	–	–	+
Orange-flanked Bush Robin	S	–	–	+	–
Blue Whistling Thrush	G	–	–	+	–
Ferruginous Flycatcher	C	–	–	-	+
Rufous-gorgeted Flycatcher	S	–	–	+	–
White-throated Fantail	G	–	–	+	+
Rufous-bellied Niltava	C	–	–	-	+
Streaked-breasted Scimitar Babbler	S	–	–	+	–
Yellow-cheeked Tit	C	–	–	–	+
Black-throated Tit	C	–	–	+	+
Chestnut-crowned Laughingthrush	G	–	–	+	+
Streaked Laughingthrush	G	–	–	+	+
Red-billed Leiothrix	C	–	–	+	+
Blue-winged Minla	C	–	–	–	+
Rufous-winged Fulvetta	C	–	–	–	+
Rusty-fronted Barwing	C	–	–	+	+
Striated Yuhina	C	–	–	–	+
Fire-breasted Flowerpecker	C	–	–	+	–
Scarlet-backed Flowerpecker	C	–	–	+	–
Crimson Sunbird	C	–	–	+	+
Fire-tailed Sunbird	C	–	–	+	–
Mrs Gould's Sunbird	C	–	–	–	+
Large-billed Crow	G	–	–	–	+
Maroon Oriole	C	–	–	–	+
Short-billed Minivet	C	–	–	–	+
Eurasian Cuckoo	G	–	–	–	+
Rufous-breasted Accentor	G	–	–	+	–
White Wagtail	G	–	–	+	–
Dark-rumped Rosefinch	G	–	–	+	–
Stripe-breasted Woodpecker	C	–	–	+	–

The total number of species recorded in the study plots were divided into three different ecological guilds. In the pine forest study plots, there were 16 canopy species, six shrub species and nine ground species (Fig. 8.1). In the broadleaf study plots, there were 41 canopy species, 16 shrub species and 14 ground species (Fig. 8.2).

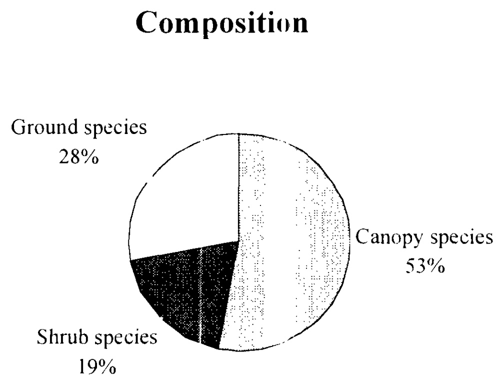


Fig. 8.1. Percentage composition of species in the three ecological guilds in the pine forest study area.

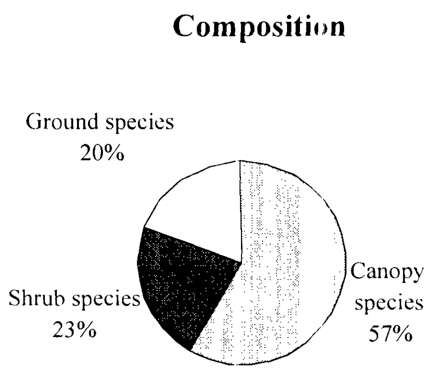


Fig. 8.2. Percentage composition of species in the three ecological guilds in the broadleaf forest study area.

8.2. BIRD ASSEMBLAGE STRUCTURE IN RELATION TO HABITAT VARIABLES

i) Pine Forest.

The Canonical Correspondence Analysis (CCA) was performed on a matrix of 32 bird species and 9 habitat variables in pine forest. The result indicated that the two axes explained 7.1 % of variance in the species data and 63.9 % of the species-habitat relation (Table 8.5a). The correlations between habitat variables and the ordination axes are given in Table 8.5b. Two ordination diagrams were constructed to aid the visual interpretation of how sampling points (Fig. 8.3a) and bird species (Fig 8.3b) were separated along the axes. The first axis is primarily a seasonal one, and the second is determined by grazing. Not surprisingly, grass cover was higher in ungrazed plots, and cattle tracks are more frequent in grazed plots. Canopy height, number of trees, and shrub cover tend to be higher towards the ungrazed plots.

Table 8.5. a) CCA performed on a matrix of abundance of 31 bird species and 5 habitat variables, two seasons and grazed/ungrazed in the pine forest study area. Variability of bird species and habitat variables associated with the first two axes. b) Inter-set correlations of habitat variables with the first two axes.

a)	**Axis 1**	**Axis 2**
Eigenvalues	0.47	0.20
Species-habitat correlations	0.86	0.67
Cumulative % variance of species data	5.00	7.10
Cumulative % species-habitat relation	44.70	63.90

b) **Habitat variables**	**Axis 1**	**Axis 2**
Canopy height	-0.086	-0.200
% grass cover	0.023	-0.422
Frequency of cattle track	0.154	0.036
% of understorey shrub	0.026	-0.023
Number of trees	-0.030	-0.184
Grazed	0.161	0.586
Ungrazed	-0.161	-0.586
Winter	0.837	-0.130
Spring	-0.837	0.130

The position of the sampling points (represented by a small cross) in the ordination diagram (Fig. 8.3a) is defined by the presence of similar bird assemblages in relation to the habitat variables. The ordination diagram of the pine forest displayed a pattern of segregation of sampling points into four fairly distinct clusters that correspond to grazed, ungrazed, spring and winter (Fig. 8.3a). This indicates that the sites in ungrazed plots (bottom left of Fig.8.3a) are distinctively different in bird assemblages from those in grazed plots (top left of Fig 8.3b). From the species ordination diagram (Fig. 8.3b), it becomes clear that a collection of species, such as Striated Prinia (SP), Hill Prinia (HP), Verditer Flycatcher (VF) and Black Drongo (BD), are associated with the ungrazed plots and another group of species, such as Grey-chinned Minivet (GCM), Little Bunting (LB), Pied Bushchat (PBC), Chestnut-tailed Starling (CTS), Rosy Pipit (RP) and Large-billed Crow (LBC) occur mainly in grazed plots. Furthermore, there is a substantial changeover of species between winter and spring. The separation of sampling points into groups of spring and winter were even more discrete. Spring visitors, such as Oriental Magpie Robin (OMR), Slender-billed Robin (SBR), Black Bulbul (BB) and Ashy Drongo (AD) occur more towards the left of the ordination diagram. In contrast, Blue-fronted Redstart (BFRS), Ashy-throated Warbler (ATW), Olive-backed Pipit OBP, Blyth's Leaf Warbler (BLW) and Green-backed Tit (GBT) occurred more often in winter and fall to the right of the diagram (Fig 8.3b).

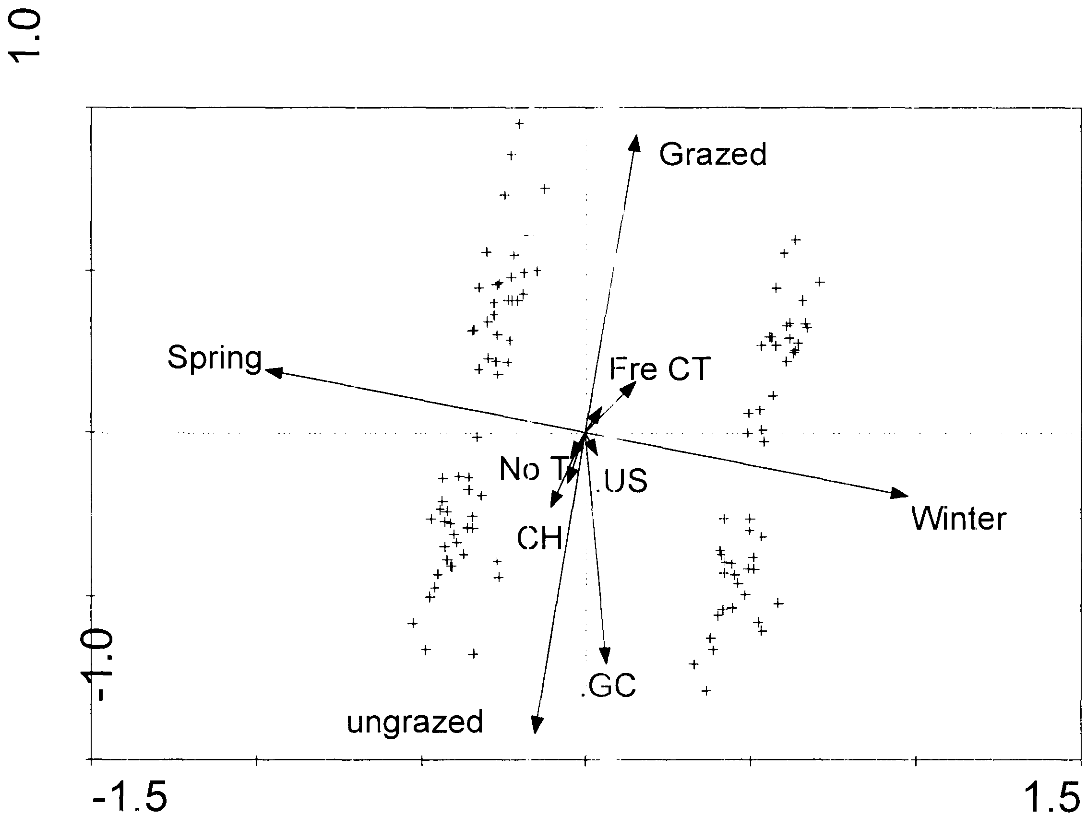


Fig. 8.3a. Canonical Correspondence Analysis (CCA) ordination diagram of the pine forest with 120 sampling points (+) and 9 habitat variables (arrows) in the pine forest study area; first axis is horizontal, second axis is vertical. Longer arrows exhibit a greater correlation between the ordination axes and the habitat variables than the short arrows and are therefore explaining the observed variation in site composition observed in the diagram. The composition of bird communities in each site is defined by the position of sampling points (+) with respect to the habitat variables. The habitat variables are: CH = canopy height, No. T = number of trees, US = % of understorey, Fre CT = frequency of cattle track, GC = herb/grass cover, spring, winter, grazed and ungrazed.

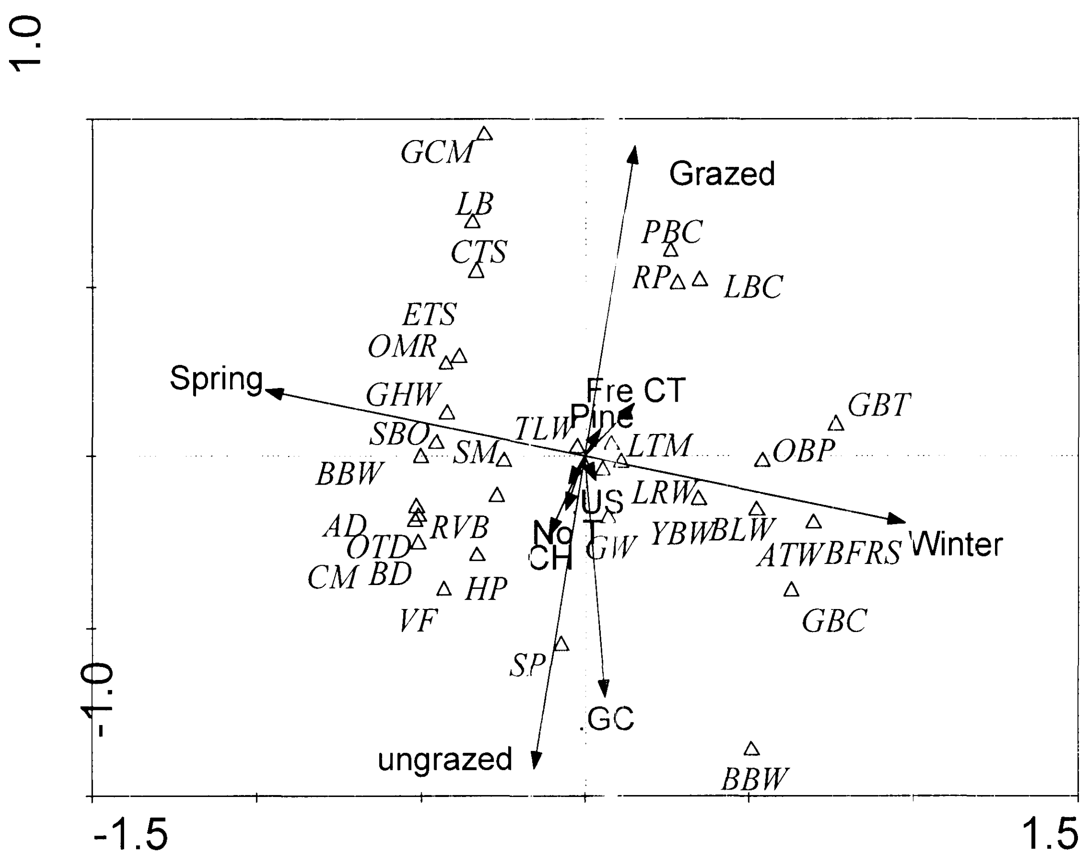


Fig. 8.3b. Canonical Correspondence Analysis (CCA) ordination diagram of the pine forest with 31 bird species (small triangle) and 9 habitat variables (arrows) in the pine forest study area; first axis is horizontal, second axis is vertical. The habitat variables are as in Fig. 8.3a. The bird species shown are: AD = Ashy Drongo, ATW = Ashy-throated Warbler, BB = Black Bulbul, BD = Black Drongo, BFRS = Blue-fronted Redstart, BLW = Blyth's Leaf Warbler, CM = Common Myna, CTS = Chestnut-tailed Starling, ETS = Eurasian Tree Sparrow, GBC = Grey Bushchat, GBT = Green-backed Tit, GCM = Grey-chinned Minivet, GW = Greenish Warbler, GHW = Grey-hooded Warbler, HP = Hill Prinia, LB = Little Bunting, LBC = Large-billed Crow, LRW = Lemon-rumped Warbler, LTM = Long-tailed Minivet, OTD = Oriental Turtle Dove, OMR = Oriental Magpie Robin, Olive-backed Pipit, PBC = Pied Bushchat, RVB = Red Vented Bulbul, RP = Rosy Pipit, SP = Striated Prinia, SBO = Slender-billed Oriole, SM = Scarlet Minivet, TLW = Tickell's Leaf Warbler, VF = Verditer Flycatcher, YBW = Yellow-browed Warbler.

ii) Broadleaf Forest

The Canonical Correspondence Analysis (CCA) was performed on a matrix of 71 bird species and nine habitat variables. The results included that the two axes explained 6.1 % of the variance in species data and 53.9 % of the variance in species-habitat relation (Table 8.6a). The correlations between habitat variables and ordination axes are given in Table 8.6b.

Table 8.6. CCA performed on a matrix of abundance of 71 bird species and five habitat variables, two seasons and grazed/ungrazed in the broadleaf forest study area. a) Variability of bird species and habitat variables associated with the first two axes. b) Inter-set correlations of habitat variables with the first two axes.

a)	**Axis 1**	**Axis 2**
Eigenvalues	0.39	0.36
Species-habitat correlations	0.67	0.47
Cumulative % variance of species data	4.00	6.10
Cumulative % species-habitat relation	34.70	53.90

b) Habitat Variables	**Axis 1**	**Axis 2**
Canopy height	0.039	-0.003
% grass cover	-0.018	-0.160
Frequency of cattle track	-0.019	0.605
% of understorey shrub	0.044	-0.045
Number of trees	0.192	-0.017
Grazed	-0.134	0.780
Ungrazed	0.134	-0.780
Winter	0.867	0.070
Spring	-0.867	-0.070

Two ordination diagrams (Figs. 8.4a and 8.4b) were constructed for the pine forest. Similarly, the first axis is primarily a seasonal one, and the second is determined by grazing (Fig. 8.4a). Grass cover and understorey, however, are not very important variables in determining the position of species and sampling points but they are correlated with ungrazed plots. The frequency of cattle tracks correlated with the grazed plots.

In the broadleaf sampling point ordination diagram (Fig. 8.4a), the pattern of separation of sampling points was almost similar to that in pine forest (Fig. 8.3a). The species ordination diagram indicates that species such as Tickell's Leaf Warbler (TLW), Black Bulbul (BB), Long-tailed Shrike (LTS), Rosy Pipit (RP), Grey Bushchat (GBC), Maroon-backed Accentor (MBO), Rufous-breasted Bush Robin (RBBR), Large Niltava (LN) and Common Green Magpie (CGM) were associated highly with the grazed habitat variables (top left of Fig. 8.4b). However, it must be noted that the latter three species were recorded on only one or two occasions. Others such as the Streaked Laughingthrush (SteLT), Striated Yuhina (SY), Mrs Gould's Sunbird (MGSB), Blue Whistling Thrush (BWT), Rufous-bellied Niltava (RBN), Rusty-fronted Barwing (RFBW) and Maroon Oriole (MO) were located towards the ungrazed plots (bottom of Fig 8.4b).

Furthermore, the pattern of separation of points representing birds was more distinct for the seasons than for the plots. This suggests that that the arrangements of sampling points are influenced strongly by seasonal differences in bird occurrence. A collection of species, such as Grey-winged Blackbird (GWBB), Indian Blue Robin (IBR), Ashy Drongo (AD), Grey-bellied Tesia (GBTes), White-browed Shrike Babbler (WBSB), Golden-spectacled Warbler (GSW), Ferruginous Flycatcher (FF), Short-billed Minivet (SBM), Eurasian Cuckoo (EC), Chestnut-tailed Minla (CTM) and Scarlet-breasted Flowerpecker (SBF) tended to stand towards spring and others such as Blue-fronted Redstart (BFRS), Rufous-gorgeted Flycatcher (RGF), Fire-breasted Flycatcher (FBF), Orange-flanked Bush Robin (OFBR), Chestnut-crowned Laughing Thrush (CCL), Rufous-breasted Accentor (RBA) and Streaked-breasted Scimitar Babbler (SBSB) occur more towards winter.

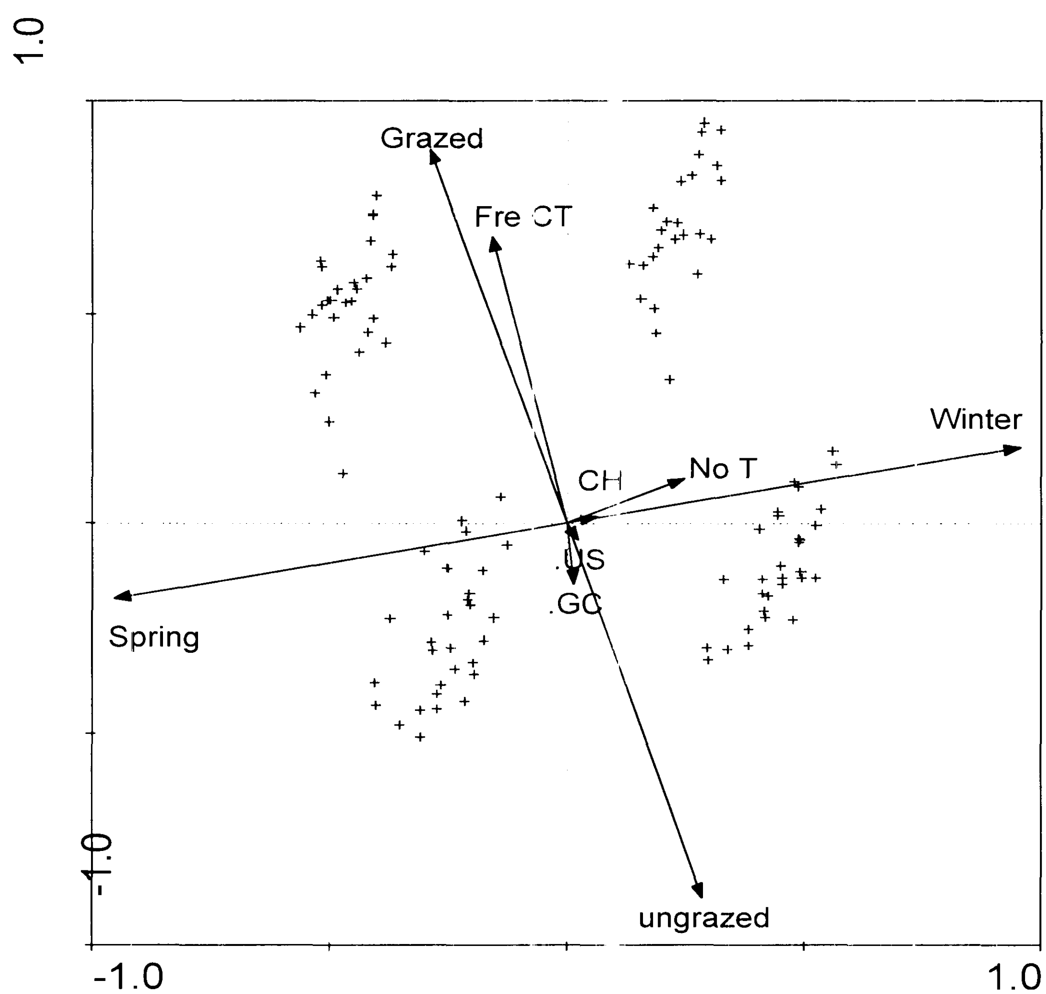


Fig. 8.4a. Canonical Correspondence Analysis (CCA) ordination diagram of broadleaf forest with 120 sampling points (+) and 9 habitat variables (arrows) in broadleaf study area; first axis is horizontal, second axis is vertical. Longer arrows exhibit a greater correlation between the ordination axes and the habitat variables than the short arrows and are therefore explaining the observed variation in site composition observed in the diagram. The composition of bird communities is defined the position of sampling points (+) with respect to the habitat variables. The habitat variables are: CH = canopy height, No. T = number of trees, US = % of understorey, Fre CT = frequency of cattle track, GC = herb/grass cover, spring, winter, grazed and ungrazed.

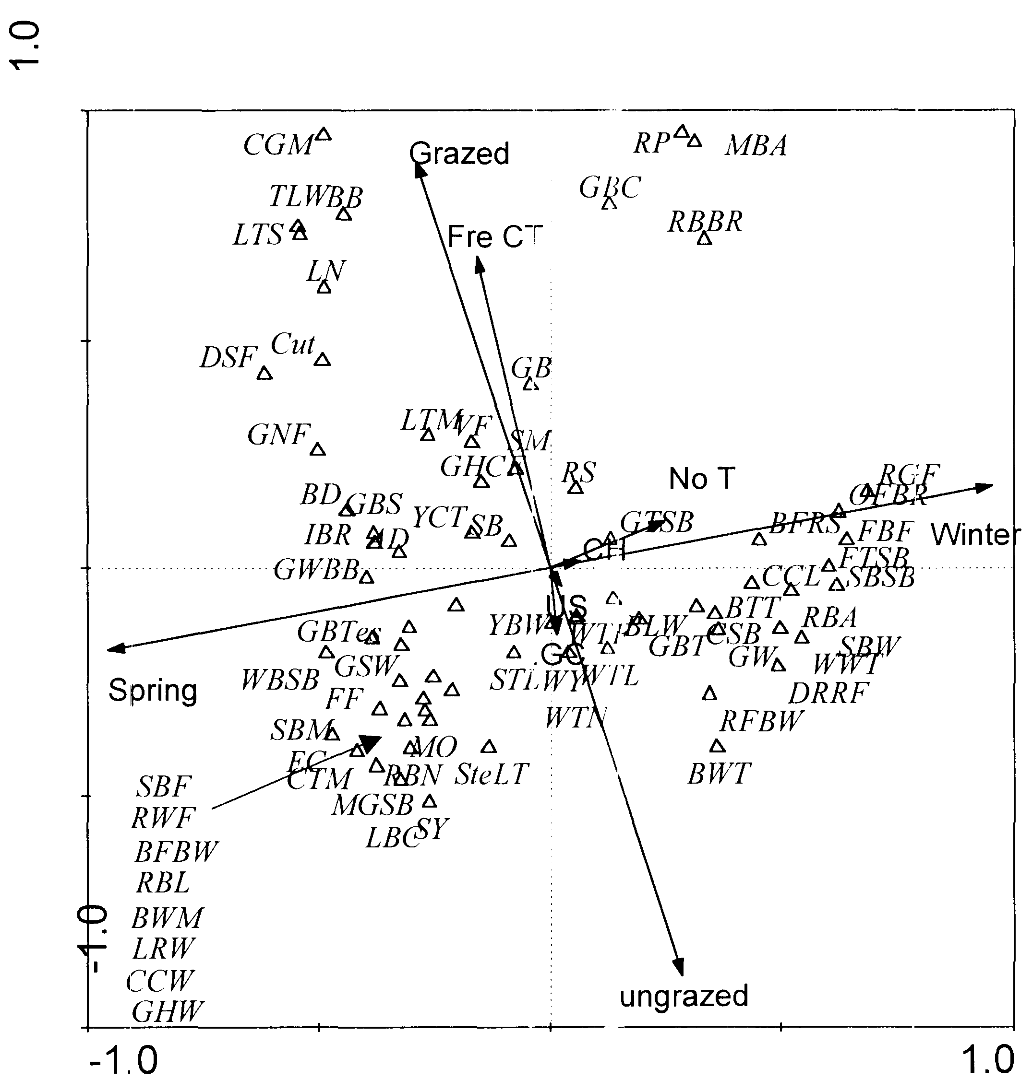


Fig. 8.4b. Canonical Correspondence Analysis (CCA) ordination diagram of the broadleaf with 71 bird species (small triangle) and 9 habitat variables (arrows) in broadleaf study area; first axis is horizontal, second axis is vertical. The habitat variables are as in Fig. 8.4a. The bird species shown are: AD = Ashy Drongo, BB = Black Bulbul, BD = Black Drongo, BFBW = Brown-flanked Bush Warbler, BFRS = Blue-fronted Redstart, BLW = Blyth's Leaf Warbler, BTT = Black-throated Tit, BWM = Blue-winged Minla, BWT = Blue Whistling Thrush, CCL = Chestnut-crowned Laughingthrush, CCW = Chestnut-crowned Warbler, CGM = Common Green Magpie, CSB = Crimson Sunbird, CTM = Chestnut-tailed Minla, Cut = Cutia, DRRF = Dark-rumped Rosefinch, DSF = Dark-sided Flycatcher, EC = Eurasian Cuckoo, FBF = Fire-breasted Flowerpecker, FF = Ferruginous Flycatcher, FTSB = Fire-tailed Sunbird, GB = Great Barbet, GBC = Grey Bushchat, GBS = Grey-backed Shrike, GBT = Green-backed Tit, GTSB = Green-tailed Sunbird, GBTes = Grey-bellied Tesia, GW = Greenish Warbler, GWBB = Grey-winged Blackbird, GHCF = Grey-headed Canary Flycatcher, GHW = Grey-hooded Warbler, GNF = Golden-naped Finch, GSW = Golden-spectacled Warbler, IBR = Indian Blue Robin, LBC = Large-billed Crow, LN = Large Niltava, LRW = Lemon-rumped Warbler, LTM = Long-tailed Minivet, LTS = Long-tailed Shrike, MBA = Maroon-breasted Accentor, MGSB = Mrs Gould's Sunbird, MO = Maroon Oriole, OFBR = Orange-flanked Bush Robin, RBA = Rufous-breasted Accentor, RBN = Rufous-bellied Niltava, RBBR = Rufous-breasted Bush Robin, RBL = Red-billed Leiothrix, RFBW = Rusty-fronted Barwing, RGF = Rufous-gorgeted Flycatcher, RP = Rosy Pipit, RS = Rufous Sibia, RWF = Rufous-winged Fulvetta, TLW = Tickell's Leaf Warbler, SBF = Scarlet-

backed Flowerpecker, SBM = Short-billed Minivet, SBSB = Streaked-breasted Scimitar Babbler, SB = Striated Bulbul, SBW = Stripe-breasted Woodpecker, SM = Scarlet Minivet, SteLT = Streaked Laughingthrush, SLT = Striated Laughingthrush, SY= Striated Yuhina, VF = Verditer Flycatcher, WWT = White Wagtail, WBSB = White-browed Shrike Babbler, WY = Whiskered Yuhina, WTF = White-throated Fantial, WTL = White-throated Laughingthrush, WTN = White-tailed Nuthatch, YBW = Yellow-browed Warbler, YCT = Yellow-cheeked Tit.

8.3. SPECIES RICHNESS AND SEASONAL VARIATION

Species richness was significantly different between forest types. Generally, there was higher species diversity in broadleaf than pine forest. The analysis of simple main effect showed that there was a significant difference in species richness between grazed and ungrazed plots in the broadleaf forests only (F = 9.08). The mean number of species per sample point in ungrazed plots was much higher than the grazed plots in broadleaf forest (Fig. 8.5). The differences in species richness between the grazed and ungrazed plots in pine forest were not significant (F = 1.84).

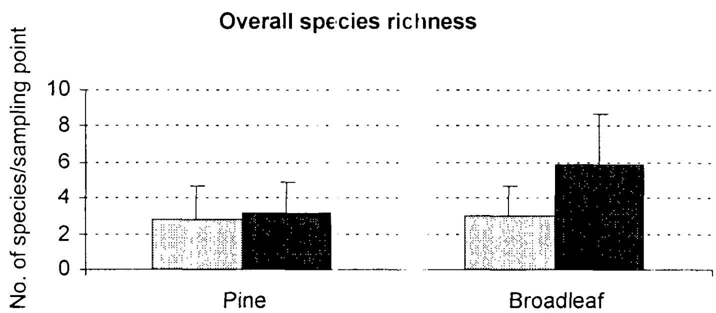


Fig. 8.5. Mean number of overall bird species per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

There were significant effects of forest type (pine/broadleaf) and plot (grazed/ ungrazed), and a forest type by plot interaction on the richness of canopy species (Table 8.8). There were more canopy species in ungrazed plots in each of the forest types (Fig. 8.6). There were more shrub species in ungrazed than in grazed plots, but forest types did not differ in number of shrub species, nor was there a forest type by plot interaction (Table 8.9, Fig. 8.7). For ground species there were significant differences between forest types and interactions between forest type and plot, but not overall between plots (Table 8.10). The number of ground species was higher in ungrazed plots in broadleaf forest, but the reverse is true in the pine forest (Fig.8.8).

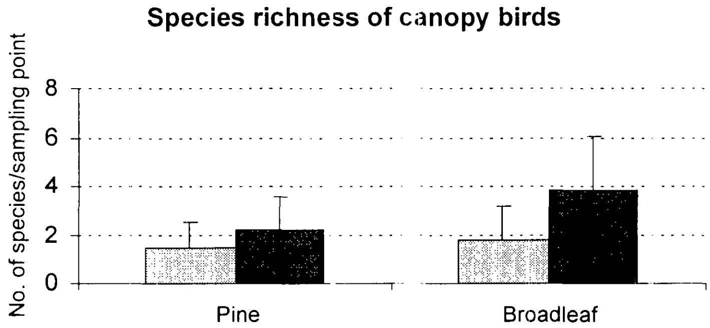


Fig. 8.6. Mean number of canopy bird species per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

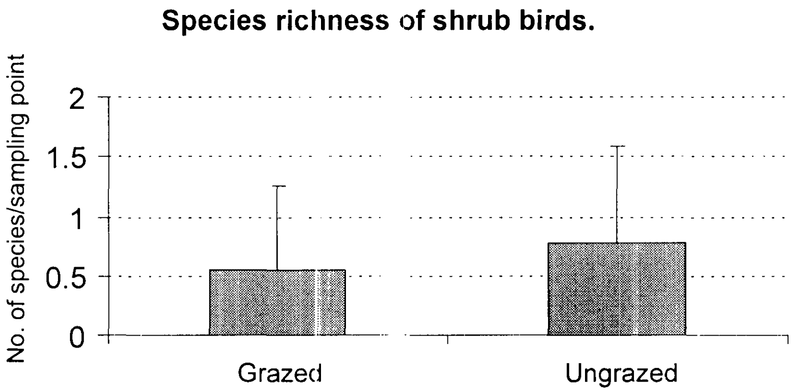


Fig. 8.7. Mean number of shrub bird species per sampling point in ungrazed and grazed plots (forest types combined as they did not differ significantly).

Table 8.7. The results of a repeated-measure ANOVA for overall species richness and abundance in grazed and ungrazed plots in pine and broadleaf forests study area in Bhutan. The results of Levene's homogeneity of variance test and subsequent data transformation are also given.

	Species Richness				Abundance			
Source of variation	Df	MS	F	P	df	MS	F	P
Forest type (F)	1	8.822	22.70	***	1	2.766	23.95	***
plots (P)	1	11.582	29.80	***	1	2.703	23.40	***
F x P	1	5.090	13.10	***	1	2.577	22.31	***
Error	116	0.388			116	0.116		
Season (S)	1	23.080	114.81	***	1	2.425	45.28	***
F x S	1	0.002	0.01	Ns	1	0.050	0.94	ns
P x S	1	0.021	0.11	Ns	1	0.093	1.74	ns
P x H x S	1	0.916	4.56	*	1	0.022	0.41	ns
Error	116	0.201			116	0.053		
Levene's Test			4.76**				18.87***	
Transformation	Square-root.				Log.			

* P < 0.05, ** P < 0.01, *** P < 0.001, ns P > 0.05.

Table 8.8. The results of a repeated-measure ANOVA for canopy bird species richness and abundance in grazed and ungrazed plots in pine and broadleaf forests study area in Bhutan. The results of Levene's homogeneity of variance test and subsequent data transformation are also given.

	Species Richness				Abundance			
Source of variation	Df	MS	F	P	Df	MS	F	P
Forest type (F)	1	6.564	17.19	***	1	35.292	23.61	***
Plot (P)	1	14.422	37.76	***	1	41.964	39.96	***
F x P	1	2.466	6.45	**	1	23.322	22.21	***
Error	116	0.382			116	1.050		
Season (S)	1	13.831	51.43	***	1	14.762	21.73	***
F x S	1	0.002	0.01	Ns	1	0.385	0.57	ns
P x S	1	0.040	0.15	Ns	1	0.471	0.69	ns
F x P x S	1	0.316	1.18	Ns	1	0.189	0.28	ns
Error	116	0.269			116	0.679		
Levene's Test			8.29***				20.80***	
Transformation	Square-root				Square-root.			

* P < 0.05, ** P < 0.01, *** P < 0.001, ns P > 0.05.

Table 8.9. The results of a repeated-measure ANOVA for shrub bird species richness and abundance in grazed and ungrazed plots in pine and broadleaf forests study area in Bhutan. The results of Levene's homogeneity of variance test and subsequent data transformation are also given.

	Species Richness				Abundance			
Source of variation	Df	MS	F	P	df	MS	F	P
Forest type (F)	1	0.817	1.30	ns	1	3.750	1.36	ns
Plots (P)	1	2.816	4.48	*	1	16.017	5.82	**
F x P	1	1.350	2.15	ns	1	11.267	4.10	*
Error	116	0.629			116	2.750		
Season (S)	1	2.817	5.80	*	1	8.067	3.15	ns
F x S	1	2.817	5.80	*	1	6.017	2.62	ns
P x S	1	0.017	0.03	ns	1	0.417	0.18	ns
F x P x S	1	0.017	0.03	ns	1	0.267	0.12	ns
Error	116	0.486			116	2.295		
Levene's Test			0.23^{ns}				1.005^{ns}	
Transformation		Square root				Square root		

* P < 0.05, ** P < 0.01, *** P < 0.001, ns P > 0.05.

Table 8.10. The results of a repeated-measure ANOVA for ground bird species richness and abundance in grazed and ungrazed plots in pine and broadleaf forests study area in Bhutan. The results of Levene's homogeneity of variance test and subsequent data transformation are also given.

	Species Richness				Abundance			
Source of variation	Df	MS	F	P	df	MS	F	P
Forest type (F)	1	4.267	14.82	***	1	7.329	15.18	***
Plot (P)	1	0.070	0.24	ns	1	0.010	0.02	ns
F x P	1	1.691	5.88	**	1	4.119	8.53	**
Error	116	0.278			116	0.483		
Season (S)	1	4.073	18.05	***	1	3.691	10.48	**
F x S	1	0.501	2.22	ns	1	0.828	2.35	ns
P x S	1	0.070	0.31	ns	1	0.077	0.22	ns
F x P x S	1	0.290	1.29	ns	1	0.238	0.68	ns
Error	116	0.226			116	0.352		
Levene's Test			3.412*				9.67***	
Transformation	Square-root.				Square -root.			

* P < 0.05, ** P < 0.01, *** P < 0.001, ns P > 0.05.

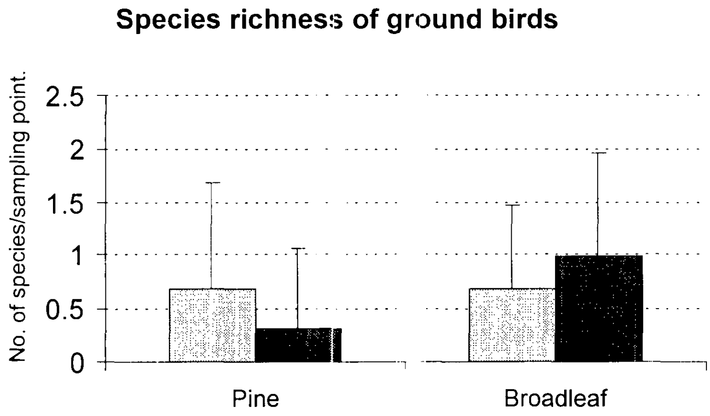


Fig. 8.8. Mean number of ground bird species per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

There was a significant seasonal variation in the richness of overall species (Table 8.7), canopy species (Table 8.8), and ground species irrespective of forest type (Table 8.10). Significantly more species were recorded in spring in all cases (Fig. 8.9). The season by forest type interaction was also significant for the richness of shrub species (Table 8.9). The number of shrub species per sample point was greater in spring in broad leaf forest but not in pine forest (Fig 8.10).

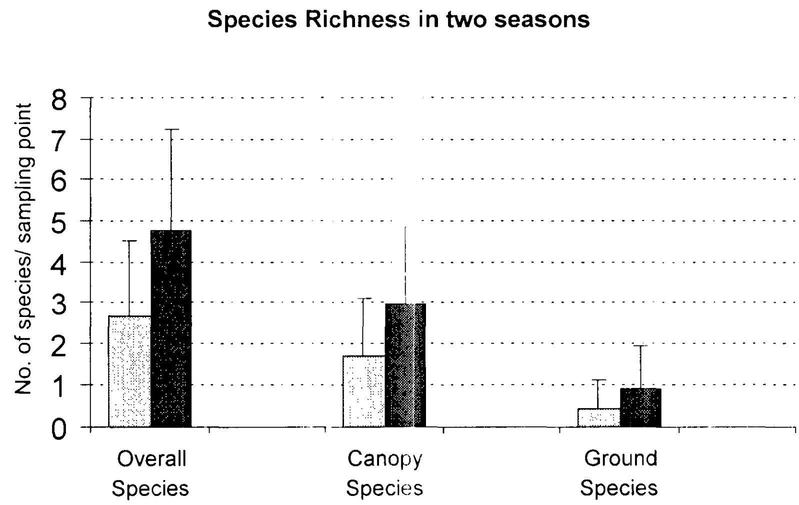


Fig. 8.9. Mean number of overall, canopy and ground species per sampling point in winter (blue) and spring (red) irrespective of forest types.

Fig. 8.10. Mean number of shrub species in pine (blue) and broadleaf forest (red) in the two seasons.

There was a significant second order interaction (season by plot by forest types) on the species richness of the overall bird species (Table 8.7). However, conservative tests such as Greenhome-Geisser's test and the Hynh-Feldt test of repeated measure factor (mean) on this did not yield any significant result and hence I did not consider this interaction further.

8.4. ABUNDANCE OF BIRDS AND SEASONAL VARIATION

The abundance of birds was significantly different between the forest type (pine/broadleaf) and between plot (grazed/ungrazed). The interactions between forest type (pine/broadleaf) and plot (grazed/ungrazed) were also significant (Table 8.7). Analyzing data separately for different forest types revealed that ungrazed plots in broadleaf forest had significantly more birds than grazed plots (F = 9.56, Fig. 8.11); but there was no significant difference between the grazed and ungrazed plots in the pine forest (F = 0.11).

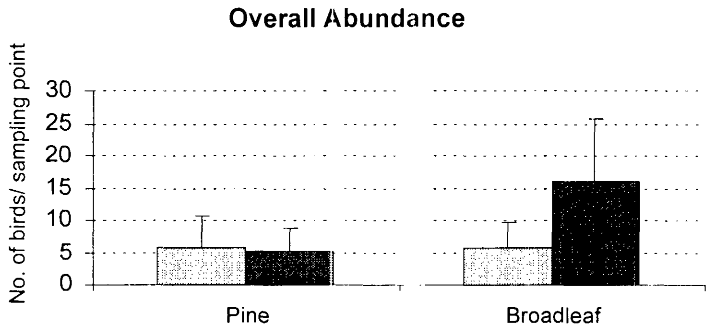


Fig. 8.11. Mean number of overall birds per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

There were also significant interactions between forest type (pine/broadleaf) and plots (grazed/ungrazed) on the abundance of canopy, shrub and ground birds (Table 8.8, 8.9 and 8.10). The mean abundance of each guild was higher in ungrazed than in grazed broadleaf forest whereas it did not differ in the pine forest, except for ground birds, which were more abundant in grazed plots (Fig 8.12, 8.13 and 8.14).

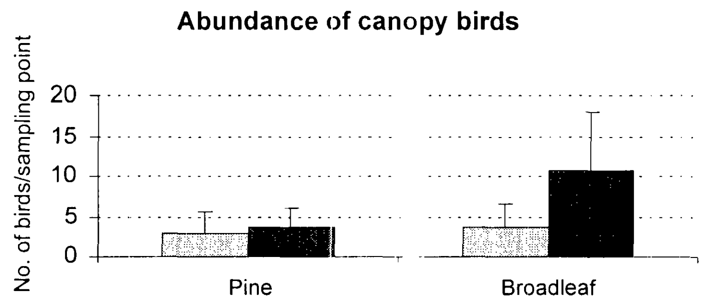


Fig. 8.12. Mean number of canopy birds per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

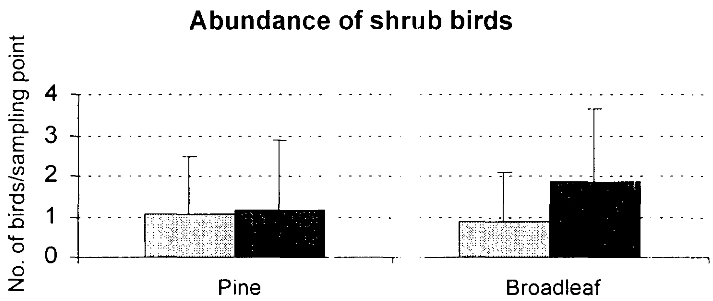


Fig. 8.13. Mean number of shrub birds per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

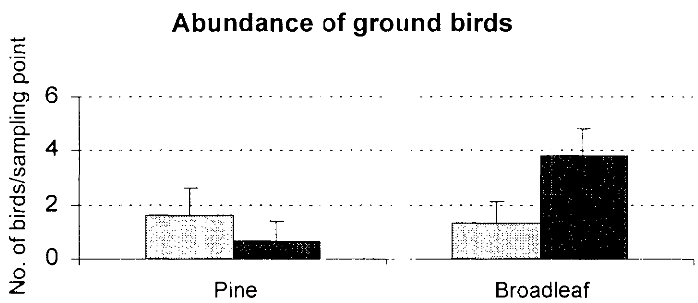


Fig. 8.14. Mean number of ground birds per sampling point in grazed (blue) and ungrazed (red) plots in pine and broadleaf forests.

There was a significant effect of season on the abundance of all birds (Table 8.7), canopy species (Table 8.8) and ground species (Table 8.10), but not shrub species. There were no significant interactions between season and forest type or plot separately or together. In all the cases, more birds were found in spring than in winter in both forest types and both grazed and ungrazed plots (Fig 8.15).

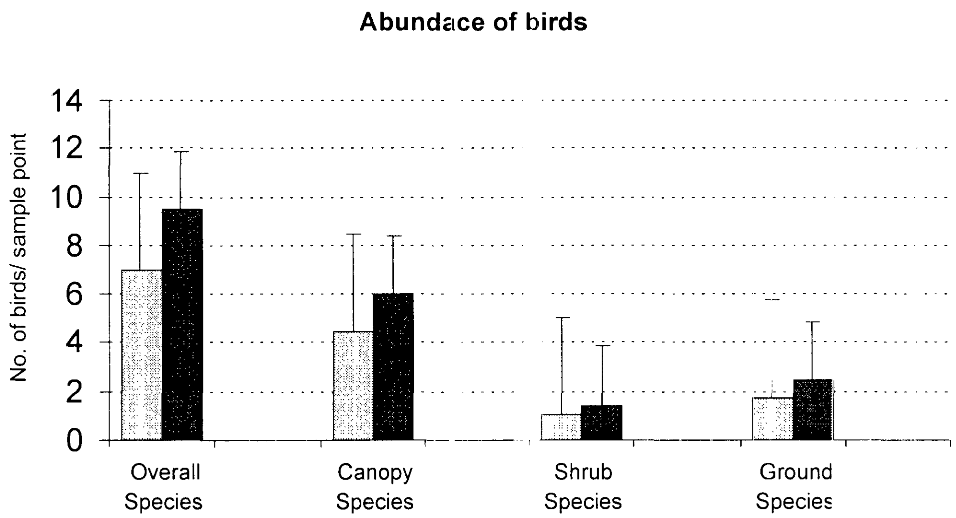


Fig. 8.15. Mean number of overall, canopy, shrub and ground bird species in winter (blue) and spring (red) irrespective of forest types.

Season did not have a significant effect on the abundance of shrub birds at the conventional level of significance of $P < 0.05$, although P equalled 0.06. There were only a few individual shrub birds in either forest type. It may be that a larger sample size would have indicated more birds in spring in this guild too.

CHAPTER 9

DISCUSSION

9.1. COMPOSITION OF BIRD ASSEMBLAGES

In Bhutan, the abundance, diversity, and the composition of bird assemblages were different in the two forest types: – broadleaf and chir pine. This is not surprising as the broadleaf forest, in general, has a great diversity of trees and understorey species, which offers suitable nesting and foraging sites for a wide range of birds. In comparison, the pine forest has less habitat complexity and, consequently, fewer bird species (Inskipp *et al.*, 1999). More complex habitats are considered ecologically significant for two reasons: they provide greater potential for resource or microhabitat segregation (MacArthur *et al.*, 1966), and they provide refuges from predators and heat or strong winds (Ford and Bell, 1981; Sedell *et al.*, 1990; Bell *et al.*, 1991). Undisturbed broadleaf forest has a great diversity of primary tree species such as *Quercus, Persia, Castanopsis,* and *Michelia* (Norbu, 2000), whereas almost no other tree species occurs in pine forest except *Pinus roxburghii* (Inskipp *et al.*, 1999). However, grazing seems to have a different effect on the composition of the bird assemblages in the two forests.

The current study showed that the composition of bird assemblages in pine forest is different between grazed and ungrazed sites. Only the Verditer Flycatcher was exclusively present in ungrazed sites. In addition, two shrub species, the Striated and Hill Prinia, and a canopy species, the Black Drongo, were associated with the ungrazed sites in the ordination diagram (Fig. 8.3b). Striated and Hill Prinia are commonly found in open forest with scrub and long grasses and the Hill Prinia is known to breed in chir pine forest (Inskipp, *et al.,* 1999). The ungrazed sites in the pine forest therefore offer suitable habitat consisting of fairly open forest and long grass cover. This is indicated in the ordination diagram (Fig. 8.3a), where the extent of grass cover showed high association with the ungrazed sites in pine forest. The Verditer Flycatcher and Black Drongo are canopy foragers and their association with ungrazed sites may be because of the availability of suitable foraging and nesting sites.

Six species that occurred exclusively in grazed sites were four ground foragers (Rosy Pipit, Little Bunting, Chestnut-tailed Starling and Large-billed Crow), one shrub forager (Pied Bushchat) and one canopy forager (Grey-chinned Minivet). A similar pattern was also evident for species present in grazed sites in the species ordination diagram (Fig. 8.4b). The Large-billed Crow is ubiquitous in terms of habitat, and Rosy Pipit, Little Bunting, Pied Bushchat and Chestnut-tailed Starling are all known to occur in agricultural land and near human settlement (Inskipp *et al.*, 1999, Inskipp *et al.*, 2000). Most of these are generalist or common species, which tend to be less sensitive to habitat changes than habitat specialists (Telleria & Santos, 1995). The Grey-chinned Minivet forages mainly in the canopy and its presence in grazed sites may be because the difference in canopy cover between the grazed and ungrazed sites in the pine forest is negligible. However, this species was recorded only at two sampling points, indicating sampling effect.

There are extensive differences in bird assemblages in grazed and ungrazed sites in broadleaf forest. Species exclusively present in ungrazed sites included a good proportion from each of the three ecological guilds: three shrub species, nine ground species and 22 canopy species. In addition to this, three canopy, two shrub and one ground species were recorded predominantly in ungrazed sites. A study in Malaysia and Pennsylvania on similar species indicated that most of these species, which occur in ungrazed sites, were dependent on the lower storey of forests (Casey & Hein, 1983; Ford & Davison, 1995). The ungrazed sites were undisturbed or less disturbed, along with greater habitat complexity in terms of number and density of tree and shrub species, as well as ground cover. A previous study carried out in the same study area indicated that the lightly grazed sites had the highest number of seedlings and saplings, and high densities of trees, followed by the intermediate and heavily grazed sites (Norbu, 2000). The ungrazed sites have more complex habitat than grazed sites, which provides more niches for different species to occupy, leading to shrub, ground and canopy foragers all coexisting.

Black Bulbul, Dark-sided Flycatcher, Rufous-breasted Bush Robin, Large Niltava and Common Green Magpie were recorded exclusively in grazed sites. These species have been recorded in similar kinds of forest in other parts of Bhutan by Inskipp *et al.*, (2000), so their exclusive presence in grazed sites in the study area is not easy to explain. All of these species were recorded in fewer sampling points indicating chance may have played a role. However, the Common Green Magpie is known to occur in extensively disturbed open canopy forest located near human settlement (Chetrri *et al.*, 2001). The exclusive presence of Tickell's Leaf Warbler in grazed sites is also difficult to account for as this species is known to forage in canopy. Moreover, warblers are small insectivores, which are very hard to tell apart. The most reliable method to identify them is by examination in the hand. In this study, their records were purely made by sighting and consequently there was a chance of misidentifying the species. The presence of Maroon-breasted Accentor, Rosy Pipit, Grey Bushchat and Long-tailed Shrike in grazed sites may be because most of these species are generalists or open country species occurring in wide range of habitat. The latter three species were also recorded in pastureland and around human settlement (Inskipp *et al.*, 2000). Chettri *et al.*, (2001) also recorded the Long-tailed Shrike and Grey Bushchat in heavily disturbed forests along the trekking corridor of Sikkim. The Maroon-breasted Accentor is a ground feeder and its presence in grazed sites may be because its foraging area is more available in grazed sites. Most of these species are either shrub dwellers or ground feeders. A similar pattern was also seen in the ordination diagram, indicating that these species are more frequent in grazed sites. It is also possible that these species are easier to detect in grazed sites, where the understorey or grass cover is less dense than in grazed sites.

9.2. ABUNDANCE OF BIRDS AND SPECIES

This study showed that more individual birds and species were recorded in broad leaf forest than pine. This may be linked to the availability of a wider range of niches in the broadleaf forest. Broadleaf forests, in Bhutan, are considered second only to the subtropical forests in their bird-species richness, because they hold a wide range of tree and understorey species and good proportion of ground cover. In contrast, chir pine forest has very few tree species with a poorly developed shrub layer (Inskipp *et al.*, 1999). The species richness of bird communities has often been found to be associated with greater structural heterogeneity of the vegetation, bird species diversity being positively related to the number of layers of vegetation (MacArthur, 1964; James & Wamer, 1982; Recher, 1985; Arnold, 1998; Barrett, 1995). In addition, broadleaf forests are probably more productive than pine forests, so that more species populations can be supported.

The abundance of all species, including canopy, shrub and ground species was significantly higher in ungrazed than in grazed sites in broadleaf forest, but there was no significant difference in pine forest. This is probably because broadleaf forests are more heavily grazed than the pine forests. Cattle grazing in broadleaf forests are an age-old tradition, forming an integral part of the farming system (Norbu, 2000). Cattle browse the understorey and damage seedlings and saplings in grazed areas leading to reduced vegetation in the shrub and ground layers. As a result there is a substantial difference in habitat complexity between grazed and ungrazed sites in terms of tree density, plant species and understorey cover (Ohsawa, 1991; Gibson, 1991; Chamling, 1996; Norbu, 2000). Heterogeneous sites support more bird species (Kitchener *et al.*, 1982; Loyn 1987; James & Wamer, 1982). Prolonged livestock grazing leads to a deterioration of these vegetation layers, resulting in the loss of the shrub layer, major changes to the herb layer and thinning and lack of regeneration of the tree layer (Arnold & Weeldenburg, 1998; Reid, 1999). This changes the structural layer of habitat available for birds (Casey & Hein, 1983).

Apart from grazing and trampling by cattle, the broadleaf forests are also subjected to constant lopping of trees to supplement the feed for cattle in winter. A recent study by Norbu (2000) in the same area reported a high incidence of lopping of primary and secondary tree species that destroyed the mid canopy layer of the forests. This affects the growth and quality of trees (Panday, 1982) and might affect the bird species associated with trees. That is why it is not surprising to find many canopy species were more frequent in ungrazed sites.

Grazing activity is less in pine forests and the damage to the habitat is not as obvious as in the broadleaf forests. There was no difference in the abundance of overall bird species and shrub bird species between grazed and ungrazed sites. However, a higher abundance of canopy species was recorded in ungrazed sites. This may have been due to the availability of suitable canopy with more trees in ungrazed sites. Ungrazed sites had been fenced for the last six years to allow regeneration and growth of trees. It was apparent that due to grazing and trampling regeneration of canopy trees was poor at the disturbed stands, compared with the undisturbed stands (Chettri 2000, cited in Chettri *et al.*, 2001).

Ungrazed sites in the pine forest study had more grass cover and less trampling of the understorey layer, making them more suitable for the ground and shrub dwellers. However, ground foraging birds were actually more numerous and more species diverse in grazed pine sites. This is probably because many of the ground-foragers required access to open ground. Also, ground dwellers were more conspicuous in open and clear sites. However, it is clear from this study that detailed habitat studies of a variety of species should be undertaken to understand how grazing affects the bird community.

9.3. SEASONAL VARIATION

In both forest types, there was a substantial changeover of species between winter and spring, indicating dynamic seasonal movement. There were more species of all three ecological guilds, and more individuals of canopy and ground birds in spring than in winter, in both forest types. Many species in Bhutanese forests are altitudinal or latitudinal migrants and exhibit seasonal movement (Inskipp *et al.*, 1999). About 45 percent of the total recorded species were found in both winter and spring in both forest types and were probably residents or local migrants. Some rare species may just have been recorded in one season by chance. Seasonal movement of species for foraging might have brought about such fluctuations (Chettri *et al.*, 2001).

No significant interactions between season and forest types were detected on the abundance and richness of the overall birds or on the three ecological guilds except for the shrub species. The number of shrub species per sampling point showed a more substantial increase in spring in broadleaf forests than in pine forest. This was due to nine additional species (Grey-bellied Tesia, Golden-spectacled Warbler, Indian Blue Robin, Rufous-breasted Bush Robin, Dark-sided Flycatcher, White-browed Shrike Babbler, Golden-naped Finch, Grey-backed and Long-tailed Shrike) being recorded in spring in broadleaf forest. In pine forest, the only additional shrub species was the Common Myna, which replaced the Blue-fronted Redstart in spring. The Blue-fronted Redstart is a common altitudinal migrant (Inskipp *et al.*, 1999) and is known to migrate to higher altitude than the current study site in spring (R. Pradhan, pers. comm.). Surprisingly, a study in Nepal showed no distinctive altitudinal preference by this species (Landmann & Winding, 1993). This may be because the current study area was at a lower altitude than the elevation preferred by these species.

9.4. CONCLUSION

It is apparent from the aforementioned discussion that the impact of grazing appears to be more severe on the bird communities in the broadleaf forest than in pine forest. There might be other factors unrelated to grazing that contributed to the difference in bird communities between grazed and ungrazed sites. However, it is likely that the current low level of grazing in pine forest has a negligible effect on the abundance of individual birds and species. Higher grazing intensities, though, may have an impact on the birds. The majority of birds were recorded exclusively in ungrazed sites in broadleaf forests, but only a handful was recorded in grazed sites. This reflects a wide range of habitats with greater vertical diversity of vegetation and understorey available for birds in ungrazed site in broadleaf forests.

The lopping activity of herders combined with the direct effect of cattle grazing exacerbates the impact on the vegetation and consequently brings about changes in available habitats for birds. Further studies should be carried out to gain more insight into the habitat requirements of a selection of bird species. These ecological studies will form a solid basis for sound management and conservation of the rich avifauna of Bhutan, which is recognized as an 'Endemic Bird Area.' In the meantime, it is important that some forest areas near villages are protected from grazing and other human impacts, especially in broadleaf forests.

CHAPTER 10

GENERAL DISCUSSION

The current study compared the bird communities in grazed and ungrazed sites in remnant woodland in the New England Tableland over four seasons in one year, and in two different forest types in Bhutan (Gedu & Lobesa) over two seasons in one year. Although there has been previous work on the effect of grazing in Australian woodlands (Ludwig *et al.*, 2000; Jansen *et al.*, 2001), there has been no previous investigation of the subject in Bhutan. The Australian study sites are in eucalypt woodland with a scattered shrub layer such as the Fern-leaf Wattle *Acacia filicifolia*, Blackthorn *Bursaria spinosa,* Sifting Bush *Cassinia quinquefaria* and regenerating eucalypts. In the Australian study region, the grazed sites had similar tree stands and understorey as ungrazed sites.

The study in Bhutan was carried out in two different forest types: the evergreen broadleaf forest, which falls under the forest type of Warm Temperate Zone and the Subtropical Xerophytic Chir pine (Pinus roxburghii) forest. Very little is known about the avifauna of Bhutan, but Inskipp *et al.*, (1999) regarded the former forest type as rich in bird diversity, including globally threatened species and restricted range species.

The current study found that the abundance and diversity of bird species did not differ significantly between grazed and ungrazed sites in New England, Australia. On the other hand, greater species diversity and higher bird abundances were found in ungrazed sites than in grazed sites in broadleaf forest in Bhutan. Australian eucalypt forests and pine forests in Bhutan had only a few species that were found more frequently in ungrazed sites (i.e. seven species in ungrazed New England woodland

and only one in ungrazed pine forest). However, broadleaf forest had a large number of species that appeared to prefer ungrazed sites (i.e. 41 species, with 35 occurring only in ungrazed broadleaf forest). All sites had few species that were more frequent in grazed sites.

Although there were some differences in grazed and ungrazed sites in bird communities in pine forest, they were less marked than in broadleaf forest. Although bird communities probably respond to the influences of grazing over longer time scales than just the current year, it is possible that current grazing impacts reflect those that have been experienced in the past, at least in relative terms (Jansen *et al.*, 2001). With low grazing activity in pine forests, this seems to suggest that the effect of grazing on birds in the broadleaf forest study area in Bhutan is much greater than the New England study area in Australia. There may be many reasons that could account for the above.

1. **Grazing and Clearing**

In Bhutan, especially in broadleaf forest, the activity of grazing occurs in conjunction with frequent lopping of trees for leaf fodder in winter. A recent study in the broadleaf site confirmed that there was a high incidence of lopping on heavily grazed sites (Norbu, 2000). Gibson (1991) estimated that almost 40% of animal feed in the study region is obtained from tree leaves. Fodder trees are the only source of forage for the cattle in winter when grasses and other edible herbage dry up (Norbu, 2000). This could seriously affect the bird species that depend upon the canopy layer; this is reflected in the more frequent presence of many canopy species in ungrazed sites. This probably contributed to the significant difference in bird abundance found between grazed and ungrazed sites. Studies in other parts of the world have revealed that the loss of canopy cover through tree death has adverse effect on small passerines (Arnold & Weeldenburg, 1998). Trees are not lopped in the pine forests in Bhutan and grazing only affects the ground layer.

Clearing of native vegetation in New England Tableland commenced with early settlement by graziers in the 1830s (Barrett *et al.*, 1994). Extensive clearing had virtually ceased by the early 1900s (Davidson & Davidson, 1992). The activity of grazing in the New England study sites did not occur concurrently with any form of clearing at present. Therefore, grazing activity alone did not appear to have an impact on the canopy layer or mid canopy layer directly. Consequently, minimal impact on the abundance of bird species was observed.

2. Type of Herbivore

Sheep are the dominant livestock in the New England study area while cattle are the dominant livestock in the two study areas in Bhutan. Because sheep crop the grass much closer to the ground than cattle, leaving much less food and fewer nest sites for birds, the type of grazing herbivores can also have a different influence on the composition of the bird community, especially on granivorous birds (Mawson & Long, 1995). However, the grazed sites in New England study area did not differ significantly in grass cover and understorey from ungrazed sites. Moderate levels of grazing appear to have less impact on the extent of herb cover, and it may also maintain species diversity in both the herbs and understorey vegetation by removing dominant plant species (Duffy, 1974; Barrett, 1995). This may favour the bird community by providing a wider range of suitable habitats. Moreover, the grazed sites in the current study in New England study area lay close to ungrazed sites, which are considered representative of original woodland near Armidale (Ford & Bell, 1981;

Ford *et al.*, 1985). Birds can, therefore, move freely between grazed and ungrazed sites, utilizing both.

In Bhutan, cattle are the dominant livestock in temperate and subtropical regions; 90% of the country's households own cattle (RGoB, 1996). It is believed that the current number of cattle far exceeds the carrying capacity of the land (Dorji, 1992). A large number of unproductive cattle are retained in herds, as Buddhist culture and belief prevents culling. As a result the grazing land is overgrazed (Gibson, 1991). Cattle browse on the understorey and could be detrimental to birds that depend on understorey. Trampling and the browsing on saplings destroy their growth and prevent regeneration of tree species; this may be detrimental to the canopy species in the long term. Several field observations in Bhutan attributed low regeneration of commercial trees in logged forests to uncontrolled grazing (FAO 1985; Millar, 1987; Ijssel, 1990).

3. Native Herbivores

Apart from livestock, the Australian vegetation is grazed by native and feral herbivores, such as kangaroos and European Rabbits, which are known to have produced devastating effects on the ecosystem (Pickard, 1991). In the New England study sites, the plots designated as ungrazed by sheep or cattle, were still being grazed by wild herbivores such as Eastern Grey Kangaroos *Macropus giganteus*, Wallaroos *Macropus robustus*, Swamp Wallabies *Wallabia bicolorr*, and Brown Hares *Lepus capensis* (Ford *et al.*, 1985). However, a recent survey in Newholme, where my study plots are located, showed that the density of kangaroos is no higher in the ungrazed sites than in grazed sites (S. Cairns, pers. comm.). This suggests that lack of a major difference in bird species abundance between grazed and ungrazed sites was not due to differences in grazing pressure by native or feral herbivores between the two types of sites.

Not much is known about the presence of native herbivores in the study sites in Bhutan and it is therefore hard to comment on their relative density in grazed and ungrazed sites. A study in Pennsylvania revealed that the effect of heavy browsing of ungulates was greatest on those bird species primarily associated with undergrowth (Casey & Hein, 1983). Hence, exploring further the type, density and preferable grazing ground of native ungulates is needed to provide useful information about grazing pressure on vegetation and consequently on bird communities in Bhutan.

4. Inherent difference in pasture land

Barrett (1995) stated that the areas in New England under pastoral use are usually on richer soil and at a lower altitude than ungrazed areas. There are no pre-grazing data available and my approach assumes that the bird species diversity and abundance at grazed and ungrazed plots were similar prior to grazing by livestock. Sites that are now grazed may originally have had a richer fauna than sites that have remained ungrazed; that is there may have been some initial differences in the bird communities between the areas before the commencement of intense grazing. If this is true, then the lack of an observed difference between the grazed and the ungrazed sites may actually mask a significant impact of grazing.

In Bhutan, there is little indication of deliberate selection of grazing land, though very little is known about this. However, there is a tendency to choose sites in broadleaf forests with good fodder trees such as *Ficus, Acer, Amoora, Castanopsis. Evoda, Macropanax* and *Pronus*, and palatable shrubs such as *Pilea, Viola. Aconogonon, Rubus, Gerardinia, Elastostema, Persicaria, Labiatae sp., Aporosa* and

Solanum for grazing. On the other hand, there is little indication that grazing in pine forest in Bhutan is selective in any way.

5. Adaptability of birds

The ungrazed sites in Australia were much more open than the ungrazed sites in Bhutan, so the effect of grazing on the structure of the vegetation was much less marked. Furthermore, eucalypt woodlands experience quite frequent fires that remove vegetation in the shrub and ground layers. Australian woodland birds may be better adapted to open habitats; disturbance in their habitat appears to affect only a few species that depend on understorey for nesting and foraging (Ford & Bell, 1981; Reid, 1999; Recher & Lim, 1990). Not much is known about the adaptability of birds in Bhutan. However, fires are rare in pine forest and almost unknown in broadleaf forests. Studies on related bird species in other parts of the world revealed that species of the lower storeys of the forest and canopy are affected by disturbance (e.g., Ford & Davison, 1995 in Malaysia). Another long-term study in Ohio woodland showed that the abundance of breeding birds in ungrazed forest was four times greater than grazed forest (Dambach, 1944 cited in Casey & Hein, 1983).

6. Geographical Variation

The topography in Bhutan is very rugged, ascending from 100 m above sea level in the south to 7550 m in the north. Consequently there is extreme variation in climate across the country. This provides a wide variety of vegetation, which may be suitable for many different bird species. Moreover, the country's location on the junction of two major biogeographical realms – the temperate Palearctic and the tropical Indo-Malayan - means that it has a diverse avifauna. In addition, its intact forests provide suitable habitat for numerous wintering breeding species or passage migrants. There are still large tracts of ungrazed forest in Bhutan, providing a wide choice of high quality habitat for birds. Almost all the woodlands in Australia are grazed and birds have limited access to ungrazed areas of forest. Birds may have been forced to adapt to grazed sites.