International Master Programme at
the Swedish Biodiversity Centre

Master's thesis
No. 65
Uppsala 2009

Effects of management and disturbance gradients on a bird fauna in Chitwan National Park and its Buffer zone

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CBM MASTER THESES SERIES

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Abstract

Chitwan National Park pioneered a participatory model of conservation as a buffer zone management programme in Nepal. Buffer Zone Community Forests have been handed over to the community for sustainable use of resources, and provide benefits to both wildlife and people. However, there is inadequate evaluation about the impact of buffer zone programs on conservation of wildlife.

This study aimed at evaluating the effect of different disturbance gradients and forest management practices on the bird community in three management regimes; the National Park, Buffer Zone Community Forests and Buffer Zone Forests. The study also evaluated the peoples' perceptions regarding the biodiversity conservation and forest management through group discussions and key informant surveys. Point counts of birds were made in Sal and Riverine forest within the three forest management types. Habitat and landscape variables related to forest structure, human disturbance and management were also recorded.

A total of 129 species of birds were recorded in 66 plots in seven different sites. The study showed that there were large effects of a disturbance gradient (distance to settlement, grazing) on the bird community composition. A few abundant species and the total abundance of birds were positively associated to the disturbance gradient. In contrast, forest bird species were negatively associated to the disturbance gradient. Common species were positively associated to a forest management gradient (collection of dead wood, small trees), but most of the forest species avoided the managed sites. Buffer Zone Community Forests and Buffer Zone Forests harboured almost as many species as the National Park, although different species preferred the different forest management types. People were willing to conserve the biodiversity for tourism and sustainable use of forest products and also had a positive attitude towards the national park, but requested more alternative resources and the inclusion of people in the park planning processes.

Key words: Bird species diversity, buffer forest, community forest, disturbance, management, national park, peoples' perception

Contents

Introduction

Background

Exploitation of biological resources is a major source of income and livelihood support in developing countries. Biodiversity contributes to food security, health (nutritious food and medicine), ecosystem resilience, social wellbeing (religion and ceremonies), and freedom of choices (Millennium Ecosystem Assessment 2005). Therefore, biodiversity and human well-being are strongly linked with each other. Forests are the storehouses for different products and biodiversity among the biological resources.

Large areas of pristine forests and natural grasslands have been converted into agricultural land and managed forest due to human population growth and technology advancement in large parts of Europe and Asia (Bengtsson et al. 2000; Laurance 2007). The net loss of forest in Asia and the Pacific was 3.7 million hectares per year between the years 2000 and 2005 (FAO 2009). The net forest cover loss of Nepalese Terai Sal forests was 23 percent between the years 1976 and 1989 and the overall forest cover loss was 15 percent between 1976 and 2001 (Panta et al. 2008). As half of the world's terrestrial biodiversity is found in natural forest ecosystems (CBD 2004), the loss of natural forest leads to loss of a large number of organisms (Magurran 2004).

In recent decades, the international community has made commitments through different legal and non- legal instruments to conserve biodiversity at the global level. The Convention on Biological Diversity (CBD, signed by Nepal) is the major convention, which has a direct link to biodiversity and people. Similarly, the Millennium Ecosystem Assessment is a scientific base for future actions needed to conserve biodiversity, and at the same time it takes human needs into account. In recent years, community managed forest has been established in more than a hundred countries (Wily 2005). They are important sources for timber and non-timber forest products, and they conserve biodiversity.

Nepal has adopted different levels of community participation in forest management sectors since the formulation of the Master Plan for the Forestry Sector in 1988. Nepal has developed two major strategies regarding the implementation of CBD; the Nepal Biodiversity Strategy (GoN/MFSC 2002) and Nepal Biodiversity Implementation Plan (GoN/MFSC 2006). These strategies are primarily set to conserve and use biological diversity in a sustainable manner and to assure fair and equitable sharing of benefits received from these resources. These strategies emphasize the participation of local and indigenous communities, and women, in conservation of the biological

resources and a healthy environment. The Tenth Plan (2002-2007) i.e. the Poverty Reduction Strategy Paper (PRSP), focuses on reversing the degradation of biodiversity as well as solving the problem of poverty and unemployment by the use of biological resources (GoN/MFSC 2002).

Nepal has a tremendous variation in altitude (from 60 to 8848 m.a.s.l.), climatic conditions, and ecosystems within a short distance, resulting in a remarkable plant and animal diversity (Bhuju et al. 2007). 39.6 percent (5.8 million hectare) of the land area is covered by forest vegetation, including degraded forest and shrub land (GoN/MFSC 2002). There are 35 different forest types with a diverse flora (Stainton 1972 cited in GoN/MFSC 2002). There are 208 species of mammals (Baral & Shah 2008), 182 species of fish, 143 species of amphibians and reptiles (GoN/MFSC 2002) and 862 species of birds (Bird Conservation Nepal 2007) in Nepal.

The Nepalese history of protected areas is not so old, although, the first legislative measures adopted for conservation (restriction on hunting and establishment of a National Zoo), was initiated more than 150 years ago (GoN/MFSC 2002). After the enactment of the National Park and Wildlife Conservation Act in 1973, 19 percent of the total land area is currently included in the Protected Area system in Nepal. This includes nine national parks, three wildlife reserves, three conservation areas, one hunting reserve and 11 buffer zone areas (DNPWC 2007). The protected area systems only represent 80 ecosystems types out of 118 identified by Dobremez (1970 cited in GON/MFSC 2002). Among these ecosystems, forest plays a great role in Nepalese economy and forest habitats are also very species-rich and have large conservation values. An analysis of existing protected areas in the country also points out important omissions of habitat types and recommends inclusion or recognition of these areas that now are identified as "Important Bird Areas" (Baral & Inskipp 2005).

"Forest Biodiversity Conservation through Community Participation (outside Protected Areas)" is the first priority program out of thirteen programs for implementation of the Nepal Biodiversity Strategy Implementation Plan 2006-2010 (GoN/MFSC 2006). The local people are strongly dependent on forest resources for their subsistence, and forests are intricately linked with farming practices in Nepal. Participatory forest management has developed as a major strategy for sustainable forest management and livelihood support (Ojha et al. 2007). Buffer Zone Community Forest is one of the participatory forest management initiatives within the Buffer Zone management program, which has a crucial role to improve the park-people relationships (Paudel et al. 2007).

Status of the Buffer Zone Community Forestry program in Nepal

At the inception of the protected area management program, there was no community participation in management, but the fourth amendment (in 1993) of the National Park and Wildlife conservation act (GoN 1973) has provided the necessary legal framework for participatory conservation by provisioning of Buffer Zones around the Protected Areas (PA). A buffer zone is a designated area surrounding a protected area within which the resource use right is transferred to the local people in order to ensure sustainability of the buffer zones (Bajimaya 2003). Principally, buffer zones should provide forest products to the local people as a compensation for depriving from the use of resources in adjacent PAs. Buffer Zones should serve both biological as well as social objectives (Paudel et al. 2007). The local communities organize into self-governed institutions that take proactive measures for conservation and development of the Buffer Zones (Bajimaya 2003). Fifty percent of the revenue generated from the concerned protected areas is used for community development activities (DNPWC 2001). The forest area within the buffer zone is legally handed over to the local community for sustainable use. There are more than 215 (10 171 ha) Buffer Zone Community Forests that are managed by 9970 households in Nepal (DNPWC 2006). The groups have some autonomy in decision-making, and make their own rules and regulations for managing and relocating the resources. Sustainability of Buffer Zone Community Forests (hereafter called community forest) has been aimed through operational plans, as well as through restrictions like prohibition in commercialization of biomass outside the buffer zone, through banning in collection of driftwood and no establishment of forest based industries within the designed area (Paudel et al. 2007).

Woodlands in the buffer zone area, which are not legally handed over to the community and under the protection of national park authorities, called Buffer Zone Forests (hereafter called buffer forests), also serve as a source for forest product and as a secondary habitat for wildlife. Geographically and in terms of vegetation types there are no differences between national park forests, community forests and buffer forests, but in community forests there are regulations and operational plans set up by forest user groups. Buffer forests have no operational plans and they are not regularly managed, but the park authority sometimes provides forest products to the local community. National park forests are strictly protected and have comprehensive management plans. Buffer zone forests are also considered as barriers for human disturbance (Bajimaya 2003), and serve as wildlife corridors.

Rationale of the study

In a previous study carried out in Nepal (Branny & Dev 1993), it is argued that not all forest management activities by communities have maintained or improved biodiversity. It has, been reported that although the vegetation structure is mostly not so complex in community managed forest, diversity is rapidly restored through secondary succession after thinning operations (Webb & Gautam 2001). Acharya (2002) mentioned that community managed forests are promoting some tree species which are valuable for the local community, but this might have negative implications for biodiversity due to their increased dominance (Sapkota et al. 2009). Concerning heterogeneity in timber and fuelwood species (diversity of tree species), the community forest is similar to that of the parks, but it has invariably lower availability of non-timber forest products (Straedae et al. 2002). Several studies have focused on socioeconomic aspects of community managed forest (for example Malla 2000; Pokhrel & Nurse 2004; Adhikari & Lovett 2006), but there is a lack of research on species diversity in community management forest (Sapkota et al. 2009). Some community forests are generating income from tourism (Nepal & Spiteri 2008), and the effect of the increasing tourism on biodiversity is also largely unknown. Some research on the forestry aspects has been carried out in buffer zone community forests of Nepal (for example, Straede et al. 2002; Straede & Treue 2006).

Birds are considered as good indicators of effects of forest fragmentation and destruction (McWilliams & Brown 2001) as they respond quickly to the change in habitat. A majority of the Nepalese threatened birds (78 species, 59 percent of the threatened bird species) depends on forest habitats (Baral & Inskipp 2004). Fragmentation and destruction of forest is considered to be a major threat for forest birds in Nepal (Inskipp 1989). The local community aim at improving habitat conditions by planting trees and manage different habitats in the community managed forests. Restrictions in some management practices (collection of litter and dead wood) would improve conditions further, see Baral & Inskipp (2005). Irrespective of degrees of exploitation (e.g. Community forests vs. National Parks) all forests provide habitats for species with different habitat requirements. Planning of forest management at the landscape level may permit bird species to coexist in the landscape (Lent & Capen 1995), both in forest interiors and in the existing secondary forests. Several studies suggest that both stand level and landscape level variables affect diversity and composition of avian communities (for example, Berg 2002; Sallabanks et al. 2006). Comparisons of the bird fauna in forest edges and forest interiors have come to different conclusions. For example, Baldi (1996) found that bird species composition differed between interior and edge, but not the diversity. On the other hand, Jokimäki & Huhta (1996) found that fragmentation and amount of forest edges had a positive relationship with

abundance of managed forest species, edge species and habitat generalist species, but negative associations with virgin forest species and hole nesting birds. Shahabuddin and Kumar (2006) found lower diversity and abundance of birds in disturbed sites than in undisturbed sites, and also the species composition was different.

There is a substantial deficit in the government technical support to community based forest management systems (Acharya 2002). People have often been using local knowledge and skills in forest management; however this may not always be favourable for maintaining all tree species (Ojha 2002). Most forest users have limited understanding of consequences on biodiversity of different forest management operations, and documentation of effects of different management regimes on ecological consequences are lacking. Some researchers have claimed that forest user group do not have sound knowledge about forest management and equally do not have knowledge in identifying the ecological importance of forest resources (Basnet 2007). There is therefore an urgent need to investigate the impact of Buffer zone forest management on biodiversity in and around the protected areas.

People still illegally collect forest products from buffer forests and national park forests as the community forests are in degraded condition (Straede et al. 2002). Conflicts still exist between park and people after the implementation of buffer zone management programs in Nepal (Nepal & Spiteri 2008). In order to decrease conflicts between community and protected area management authorities, an important first step is to analyze perceptions and attitudes of users toward wildlife conservation and forest management. There are several causes behind existing conflicts, such as wildlife damage to crops and livestock (Mishra 1997; Maikhuri et al. 2001; Wang et al. 2006; Allendorf et al. 2007), restrictions to use park resources freely (Maikhuri et al. 2001; Allendorf et al. 2007) and exclusion of farmers from the park planning process (Wang et al. 2006). Hence, comprehensive research is needed to evaluate attitudes towards conservation and effects of buffer zone management programs, different forest management regimes, grazing and human disturbance on biodiversity in Buffer Zones and National Parks.

This study was carried out in three community forests, two buffer forests and two sites in a National Park. All the study sites have similar physiographic conditions and forest composition.

Objective of the study

The aim of the study was to analyze the bird community composition and diversity in forest habitats with different degrees of protection and to explore attitudes and opinions of the buffer zone forest user groups towards wildlife conservation. Furthermore, effects of different forest management practices,

grazing, human disturbances, forest structure and different landscape variables on the bird fauna were analyzed.
The specific objectives of the study were:

- To compare the bird fauna (community composition and diversity) in buffer zone community, buffer zone forest and national park site
- To compare the bird fauna at edges and interior part of the forest, at sites at different distances from settlements, and National Parks and to compare sites with different degrees of human disturbance
- To analyze the impact of habitat types (Sal forest and Riverine forest), forest structure and forest management practices (type of forest management and grazing) on the bird fauna
- To assess the management history and present forest management practices applied by the community
- To assess the perception of community forest user groups towards the national park and wildlife conservation

Limitations of the study

Due to the limitations in resources the study could only cover a small part of the national park and Buffer Zone Community Forests. The study was performed during September – November, which is after the period when most forest management performed by local communities are done and after the breeding period for birds (spring and summer). The study focus on forest bird species rather than grassland birds and/or wetland species. Thus, this study mainly reflects habitat use of resident forest birds after the breeding season, and it is possible that other factors than the ones identified in this study (e.g. related to nest sites, food for nestlings etc.) are more important during the breeding season. Information about forest management practices, use of different tree and plant species, perception and attitude of people towards conservation were explored through the social survey. The social survey was not designed for detailed statistical analyses, and therefore only general qualitative conclusions are drawn from it.

Study areas

A general description of the study area, selection of sites and descriptions of the selected sites is provided in this chapter.

Chitwan National Park

Chitwan National Park is located about 200 km south of Kathmandu (Fig.1). It is situated in a valley between Siwalik and Mahabharata Mountain ranges with rich and thick alluvial deposition. There are three major river systems, viz, Narayani, Rapti and Reu in the area. The climate is tropical to subtropical with a summer monsoon (mid June to late September) and relatively dry winter (Nakarmi 2007). The altitude ranges from 165 to 190 meters above sea level. Before 1940 Chitwan was covered by dense forest and it was the prime habitat of many wild animals including megaherbivores, and the area was famous for game hunting. After the malaria eradication in the 1950s, the forests of the region were rapidly destroyed and fragmented (Gurung 1984 cited in Nepal & Weber 1995). To avert this degradation, the government decided to initiate conservation actions in the region and a Rhino Sanctuary was declared in parts of the Chitwan valley. At present the area is under high pressure from tourism. Over 75 percent of the park entries are made from the Sauraha Sector where the study sites are located (DNPWC 2006).

Chitwan National Park, which was established in 1973, is the pioneer national park in Nepal. The park represents the ecosystems of the Terai and Siwalik physiographic zones of the country. The area encompasses 932 km^2 and an additional 750 km^2 of buffer zones. Initially (in 1973), Chitwan National Park covered only 544 km^2, but it was later extended to the present area (Bhuju et al. 2007). The park is one of the major tourist destinations, with more than 80 000 visitors in the fiscal year 2006-2007, which is the highest number of visitors to any protected area in Nepal (DNPWC 2007). The park has been divided into utility zone, core zone and management facility zone, which is outstanding in park management sector in Nepal (Shrestha 2006). This National Park has been listed as a natural world heritage site by UNESCO in 1984 (GoN/MFSC 2002).

The park consists of more than 70 percent Sal forest, 20 percent grasslands, 7 percent Riverine forest and the remaining area consists of wetlands (DNPWC, 2001). It harbours over 50 species of mammals, more than 500 species of birds, 49 species of reptiles and amphibians. The park is one of the prime habitats for greater one horn rhinoceros (*Rhinoceros unicornis*). It has the richest diversity of birds among protected areas of Nepal and harbours two thirds of the globally threatened bird species found in the country (Baral & Inskipp 2005). The Bees Hazari Tal, located in its buffer zone, is one of the most

important wetlands for bird, which is designated as a Ramsar site (Bhuju et al. 2007).

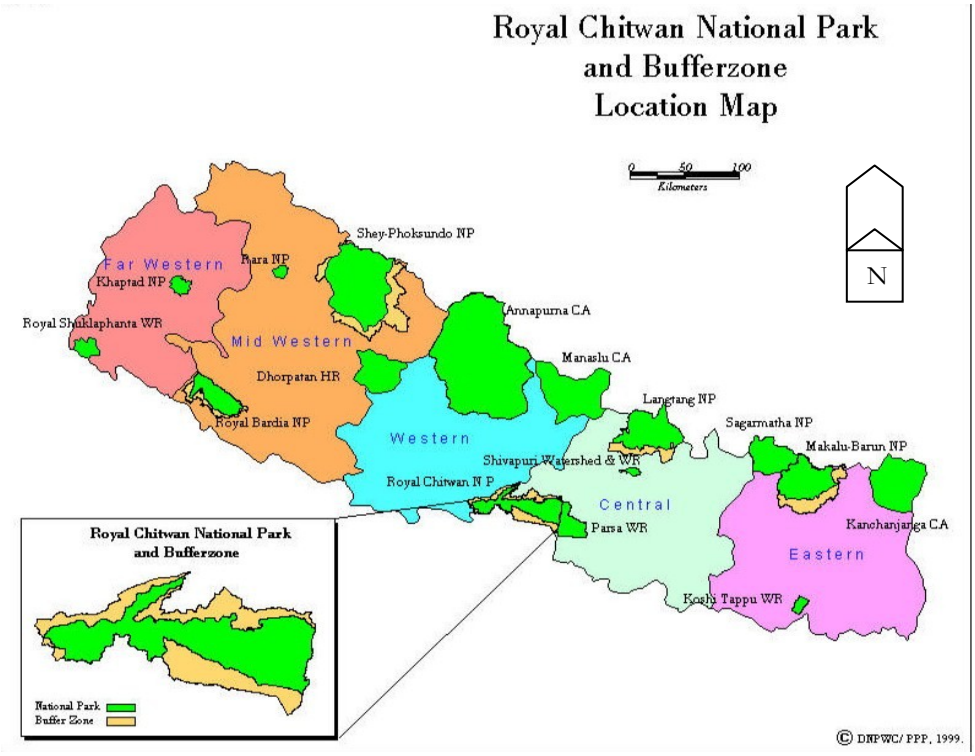

Figure 1. Map showing the location of the study area (Chitwan National Park, Nepal).

Site selection

The general study area, Chitwan National Park, was chosen after consultations with conservation experts from the Department of National Parks and Wildlife Conservation (DNPWC), Bird Conservation Nepal (BCN) and National Trust for Nature Conservation (NTNC). Specific forest sites were chosen after discussions with park managers, birdwatchers and the Buffer Zone Management Committee.

The study was carried out in community forests and buffer forests around the park where the buffer zone management program has been practiced for the last ten years. Among 36 (63 km^2) community forests (A. Bhandari pers. comm. 2009) of Chitwan National Park's buffer zone, two community forest (≥ 50 ha) with Riverine forest (dominated by Veller-*Trewia nudiflora,* Sissoo-*Dalbergia sissoo,* Simal-*Bombax ceiba* and Khair-*Acacia catechu*) and one Sal forest (dominated by Sal-*Shorea robusta,* Asna-*Terminlia alata,* Tantari-*Dillenia pentagyna,* Karma- *Adina cardifolia*) with different management activities were selected. The

criteria for choosing community forest was that the forest had been managed by the community for more than five years, that there were some tourism activities and that the forest area was 60 ha - 500 ha. Two buffer forest sites and two National Park sites located adjacent to the community forest sites (Fig. 2), with the same conditions regarding rainfall (2000-2400 mm/year) and elevation (160-170 m above sea level) were also chosen. One buffer forest site and national park site consisted of Sal forest and one in each category was Riverine forest. Altogether there were seven study sites, four with Riverine forest and three with Sal forest.

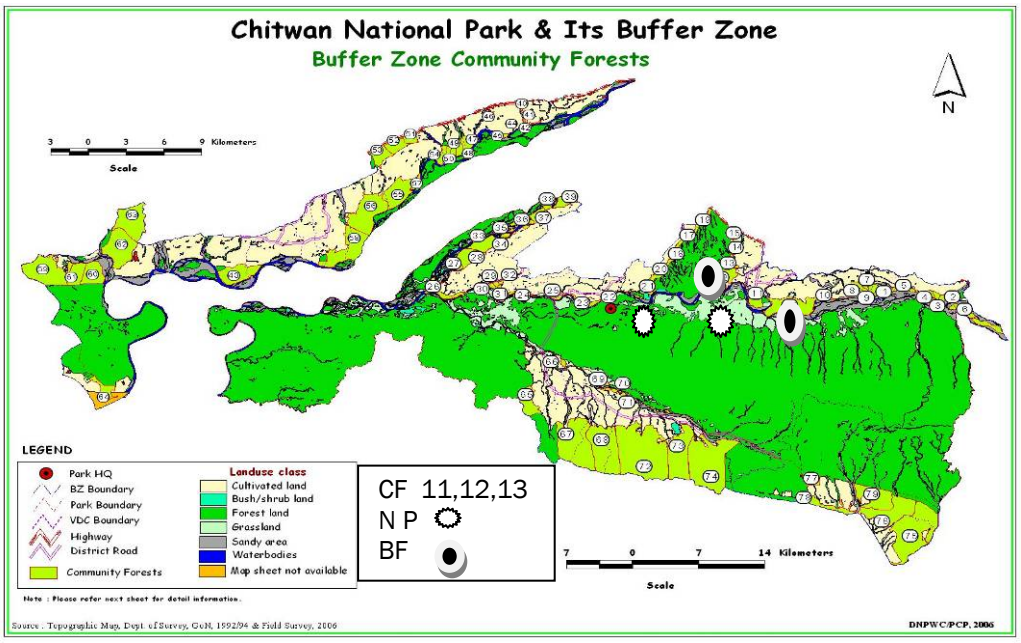

Figure 2. Map of the study sites with location the studied community forest (CF), National park (NP) site and Buffer forest (BF) sites.

Description of selected forest sites

Baghmara community forest

Baghmara community forest is located in close vicinity to Chitwan National Park. This community forest consists of 215 ha forest with Riverine vegetation. A total of 780 households have been involved in conserving and managing the forest since 1990s. Half of the households are from the "Tharu" indigenous ethnic community. The livelihood mainly depends upon agriculture and tourism, which has become a major source of income. More than 300 tourists enter the forest during the tourism peak season in a single day (mentioned in key informant survey). The user groups are performing thinning, cleaning, pruning, grass cutting and plantation as forest management activities. Grassland management include cutting and clearing of woody vegetation.

Wetland management consists of construction and maintenance of natural water holes.

Chitrasen community forest

Chitrasen community forest is situated at a distance of 2.5 km from the national park next to the Baghmara community forest. Chitrasen forest area is drier than Baghmara and it is dominated by dense Sal forest. The total forest area is 463 ha and the number of households is 811. Like in Baghmara, most of the users are from the "Tharu" community. The conservation management was initiated at the same time as in Baghmara community forest. Most of the households are affiliated to agriculture and some of them are involved in tourism too. This community forest is also one of the tourist and picnic areas. Removal of dead Sal trees; thinning and cleaning are the major forest management activities practiced by the community. It is a part of the renowned Barandavar corridor forest of Chitwan.

Jankauli community forest

The Jankauli community forest is also situated in close vicinity to the national park boundary. There are 950 households and the forest covers only 60 ha. The community forestry user group started to manage the area in the 1990s. It was then a Riverine forest degraded by grazing and overexploitation of forest resources by the local people. Since the forest area is not sufficient to fulfil all needs of the community, dead wood, branches and other forest resources are currently only used at special occasions, such as ceremonies.

Icharni Island buffer zone forest

Icharni Island is a part of buffer zone forest, which lies between the national park and Jankauli community forest, with the same forest type as Jankauli community forest. It is managed by the park authority and there is limited access for the community people. People collect firewood and grass in this area. However, there is a dispute over the access to the area. The community wants to protect it as a community forest, whereas the National Park authority wants to protect it as part of the National Park. Legally, it is not within the national park boundary.

Khorshore buffer zone forest

Khorshore forest is also a part of buffer zone forest in Barandavar corridor forest, adjoined to Chitrasen and Baghmara community forest, which connects the national park to Chitrasen and Baghmara community forest. It is a tourist site with Sal forest. This forest is managed by the national park authority; it is the major source of timber for local development activities. Dead tree removal is a major forest management activity and wetland management (creation of artificial dams in small streams) has been done in this area to improve the habitat. The grazing pressure is strong in the area.

National Park sites

National Park site one is composed by Riverine vegetation and located close to settlements at one of the major entrances for tourists in the national park. Thatch grass is allowed to cut during winter for three days in the patches of grassland inside the forest. The second national park site is composed of Sal forest and located far away (more than 5 km) from settlements. It is also used by tourist for wildlife viewing and forest walking. The extraction of trees and dead wood is strictly prohibited in both of the areas.

Methods

All quantitative data (bird species and habitat data) were collected during field surveys, whereas the social data (qualitative) were obtained from key informant surveys and group interviews. Some secondary data were collected from published sources and authorities.

Bird and habitat surveys

A systematic sampling method was used to collect data on birds, habitat composition, management and location in the landscape. A single transect was established in each forest site. The transect covered the whole forest area in order to represent the different habitats and vegetation structures in the forest. The transect length was directly related to the size and shape of the forest (Bianconi et al. 2003) i.e. the longest transect possible was selected. In each forest site, one point was randomly selected at the edge (<75 m from forest edge), and a transect covering the whole forest area was laid out from that point (modified from Pattanavibool et al. 2004). Starting from the edge point, 6-12 points (depending on size and shape of the forest) were marked at regular intervals of 200 meters. At least two points per transect were located at the edge of the forest. All transects were permanently marked (Fig. 3) before the start of the bird census and habitat mapping (Fig. 4). Global Positioning System (GPS) and markings on trees by enamel were used to locate the points. A total of 66 points were censused in the seven sites; 24 in community forests, 18 in buffer forests and 24 in the National Park. Among them 27 plots were edge plots and 39 plots were interior plots.

Birds were counted using the 50m radius point count method (Bibby et al. 1992). All birds seen and heard within five minutes were recorded. Birds that were flushed while approaching the point were also recorded. The counts were made between 07h00 to 10h30, on days with good weather conditions. The observations were made in three consecutive months i.e. September (15-30), October (15-30), and November (15-30). To avoid bias in bird observations due to time of visits the points were visited in different order in these three mornings. A group of 6-12 points (one transect) was censused in a single day. Three bird watchers were involved in the bird censuses and they visited all points at one occasion each. One assistant was following the bird surveyor in each visit and in some areas (n=24) trained domestic elephants were used due to occurrence of dangerous wildlife such as Rhinos, Tigers (*Panthera tigris*) and Elephants (*Elephas maximus*). To avoid the disturbances due to movement of the elephants, they were kept far away from transects. A bird survey protocol is presented in Appendix 1.

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Figure 3: Marking transect

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Figure 4: Marking circular plots and habitat mapping

Circular plots (Fig.4) of different size were used to measure the abundance of various sizes of trees and shrubs (Fig. 4), according to the national forest inventory guideline for Nepal 2003. A plot with a radius of 12.6 m was used to count the number of trees (> 30cm DBH); a plot with 5.6 meters radius was used to count the pole sized trees (10-29.9 cm). In similar fashion, 2.8 meter radius circular plots were used for saplings (4-9.9cm DBH). Crown cover was estimated through ocular estimation (amount of light passing through the crown). Ground cover (percentage) was measured in a 1x1 m square with the centre point as a corner of the grid (Table 1). The detailed habitat survey protocol is presented in Appendix 2.

Table 1. Description of environmental variables used in the study.

Short name	Environmental variable	Measurement description
NPFOREST	National park forest	Part of National Park
COMFOREST	Community forest	Buffer zone community forest
BUFFOREST	Buffer zone forest	Part of Buffer zone forest
SALFOREST	Sal forest	Forest area dominated by Sal trees
DISTEDGE	Distance to edge	Distance to edge from the sample plot (m)
DISTNP	Distance to national park	Distance to national park boundary from sample plot (km)
RIVERFOREST	Riverine forest	Forest area dominated by Riverine trees
DISTSETT	Distance to settlement	Distance to the nearest settlement (km)
DISTWETLAND	Distance to wetland	Distance to the nearest wetland (m)
FORMANAGEMENT	Forest management practice	Forest management practice within the sample plot
GRAZING	Grazing	Intensity of grazing within the sample plot (scale 1-3)
HUMDISTU	Human disturbance	Intensity of human disturbance (scale 1-4)
TRESPSNO	Number of tree species	Total tree species number (>30 cm dbh) within 12.6 m radius
TREFREQ	Total number of tree	Total tree number (>30 cm dbh) within 12.6 m radius
POLFREQ	Pole frequency	Total tree (> 10-29.9 cm dbh) within 5.64 m radius
SAPFREQ	Sapling frequency	Total saplings (4-9.9cm dbh) within the 2.8 m radius
SEEDFREQ	Seedling frequency	Total seedling number within 1.8m radius
ADJFORES	Adjacent forest	Sample plot with adjoining forest
ADJGRLD	Adjacent grassland	Sample plot with adjoining grassland
ADJGRWET	Adacent grassland and wetland	Sample plot with adjoining grassland and wetland
ADJFOWET	Adjacent forest and wetland	Sample plot with adjoining forest and wetland
CRCOVER	Crown cover	Crown cover (10 percent intervals)
GRCOVER	Ground cover	Percentage ground cover (1x1m plot) in 10 percent interval.
DOMDIAM	Measurement of dominant dbh class of tree	Dominating diameter of trees within 12.61 m radius
FRUITREE	Fruiting tree	Presence and absence of fruiting tree within in 12.61 m radius
DEADWOOD	Presence of dead wood	Dead wood within the 12.61m radius (scale 1-4)

dbh=diameter at breast height

The area adjoined to the sample point was categorized as forest, grassland, forest wetland, grassland wetland or settlement. The distances (m) to forest edge, national park border, settlement and wetland were estimated. The data regarding grazing intensity, human disturbance, silvicultural operations and other management operations carried by the forest users and park authority were also collected during field visits. Additional information was collected from different authorities. Grazing intensity was classified as heavy (evident signs of trampling), medium (signs of trampling and dung) or low (few signs of grazing). Human disturbance was classified as intensive (trails, observations of humans), high (small trails), medium and low (no signs of humans). Similarly occurrences of dead wood and fruiting trees were also noted. Amounts of dead wood was classified in four categories i.e. high (standing dead trees), medium (lying dead trees), low (only branches), none (no presence of any dead wood). Fruiting trees was classified as present or absent.

Social Data

Perceptions and attitudes of local people towards wildlife conservation and the national park were assessed through group discussions and key informant surveys. In most cases it was not possible to directly observe different forest management activities. Only collection of firewood and grass cutting was observed during the field study. Therefore, group interviews, key-informant interviews and data collection from authorities were used for getting information on forest management practices as well.

All together six group interviews (two for each community forest), were made with the members of the community forest user groups. The number of group interviews was based on the number of the households associated to number associated to each community forest. All of the studied community forest has 780 to 950 households so same number of group interviews were carried out in each community. The participant for group interview was selected according to age, gender and participation in different buffer zone management programs. The group interviews were conducted in concerned community forest meeting halls. The age of participants in group discussion was between 30-65 years including both women and men (Table 2). Each of the groups was selected to represent the different settlements. Most of the participants were active in the buffer zone management activities and all of them were member of the buffer zone community forest user committees.

Table 2. Gender and age composition of participants in group interviews and key informant surveys

Community forest	Interview Group	Gender		Age		
		Male	Female	25-35 years	36-45 years	46-65 years
Baghmara	first	5	3	2	5	1
	second	4	2	0	4	2
Chitrasen	first	7	1	1	4	3
	second	5	3	0	6	2
Jankauli	first	4	4	0	5	3
	second	5	3	1	4	3
Key Informants						
Buffer zone community		4	1	0	2	2
Conservationist /Bird Watchers		9	1	7	3	0
GOs and NGOs members		5	0	1	3	1

Perceptions and attitudes of the people concerning forest and wildlife conservation were discussed with the help of questions in a checklist (Appendix.3). There were 6-8 members participating in the group interviews (Fig. 5), which lasted for up to two hours in order to conduct the discussion effectively (Flick 2007). One moderator facilitated the group interview with checklist and researcher took the notes. All participants were encouraged to express their opinions during the survey.

In addition, 20 key informants were consulted for information about buffer zone forest management and conservation aspects of national parks and the buffer zone. These informants included one key informant from each community forest user committee and two key informants from Mrigakunja Buffer Zone Management Committee (BZMC), ten naturalists (bird watchers, guides) and conservationists, the remaining were from National Park offices and NGOs working with conservation in the area (Table 2). The chairperson and secretary from BZMC, three general members from community forests, ten naturalists working as nature guide and bird watcher were interviewed. Similarly, one conservation officer, one ranger and one game scout from the national park and one officer and one field worker from NGOs were interviewed. One set of questions was used for community forest user committee members and BZMC members (same as for group interview) and a different set of questions was used for conservationists; service providers (GOs and NGOs working for conservation) and park managers. These different kinds of people were interviewed since they might have different opinions on nature conservation because of the nature of their job. A detailed list of key informant questions is presented in Appendix 4 & 5. The key informant

surveys were done by the author and the information was recorded as notes (Fig. 6).

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Figure 5: Group interview

The key informant interviews were performed after the group interviews in order to get information about technical aspects of the community forest management and operational plans that community members could not be expected to know.

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Figure 6: Key informant interview

Finally, information about forest management history and conservation was received from operational plans of the community forests. Both, ongoing five years operational plans and past five years operational plans were consulted.

Data analysis

For the bird data a detrended correspondence analysis (DCA) was used in order to estimate the length of the compositional gradients in the data. The relatively long gradients (sd = 2.5-3.5) verified that unimodal models, i.e. canonical correspondence Analysis (CCA) could be used (ter Braak & Smilauer 1998; Jongman et al. 1995). A CCA was performed to analyse the position of bird species (occurring ≥ 10 sites) and habitat variables along environmental axes. The maximum number of individuals for each species and plot was used in the analysis. Only significant ($p \leq 0.05$) environmental variables are presented in graphs.

All bird species were grouped according to their main habitat and classified as forest species, edge species, open habitat species, or settlement species. Furthermore, all species were grouped according to their main food and classified as insectivores, omnivores, piscivores, raptors or frugivores. The classification for habitat is based on Birds of Nepal by Grimmett et al. (2000) and main food after the handbook of birds of the world (del Hoyo et al. 1992-2007). The system by Gill & Wright (2006) was followed for nomenclature of bird species. The classification of birds according to main habitats and main food categories was used for calculating species-richness of birds with different main habitats and main food items at each site.

Multiple regressions with backward selection of independent variables were used for analyzing species-richness of birds with different main habitat and main food categories. I used log-linear regressions with stepwise selection of variables (software JMP 6.03) by selecting generalized linear models with a Poisson distribution and a log-link function. For simplicity, and possibilities to compare with the ordination analysis, the four environmental axes from the CCA was used as independent variables, i.e. the position of each site along axis 1-4 was used as independent variables. Kruskal-Walli test (SPSS software) was used to compare the difference in bird diversity among the three forest types.

The social data was first tabulated according to category of the respondent. For one question all the answers were tabulated and denoted how many respondent that gave similar types of answers; this is later described as "a few"(approximately 30 percent), "some"(approximately 30-70 percent), and "many or most" (more than 70 percent) in the results. The interviews of community forest and Buffer Zone Management Committee members and group interviews are described together, since the checklist was the same and the purpose of the interviews was to verify the answers from the focus group

discussions. The information from ten naturalists (bird watchers, guides) and conservationists described together whereas the remaining information from key informants from National Park offices and NGOs was described separately.

Results

Forest management history (from secondary sources)

The review of operational plan of the three studied community forests showed that; until early 1970s all buffer zone community forest and buffer zone forest were covered by dense vegetation and was good habitat for Tiger, Rhino and other animals. After 1972 more and more people immigrated into the area, resulting in degradation and fragmentation of the forest. At that time, the forest area was under the jurisdiction of the district forest office, and some conservation initiatives had already been initiated in the national park forest by the government. The degradation of forest continued till early 1990s. The scarcity of forest resources became severe in the area and the pressure on the national park increased. In the mean time some conservation initiatives started, such as; fencing around the forest, management of grasslands, plantation of fodder and timber species. After the declaration of the buffer zone, the area came under jurisdiction of the park authority and was considered as a buffer zone forest and it was later handed over to the community as buffer zone community forest. The community executed the thinning, cleaning, grass cutting, plantation, weeding and other management activities in their Community Forest on a rotational basis. They divided the forest in different blocks according to vegetation and management requirement in the operational plan for each year. Now, natural regeneration of trees has been re-established and wildlife tourism is promoted and local people get significant benefit from it.

Attitude and perception of local people (group interviews and key informants)

Present forest management practice

All six studied community groups and key informants had similar views about the forest management practices. Community people remove dead wood from their forest as the major forest management activity. In Baghmara and Chitrasen community forest they remove small trees from dense forest patches as a thinning operation in favour of timber trees, but in Chitrasen forest they never remove green Sal trees. They also perform cleaning and weeding operations in their forest. They remove unwanted bushes and climbers and remove grasses around plants during weeding operation. They cut the grass in open grasslands (Fig. 7) and clean, dig and construct water holes as a wetland management. In Jankauli community forest they removed one of the invasive alien species *Mikania micrantha* and planted some cash crop beneath the trees. Baghmara community forest established its own nursery to produce seedlings.

In the inception of the buffer zone programme in Jankauli and Baghmara they planted a large area and are still planting fodder and fruiting trees.

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Figure 7: Grass cutting activities in BZCF

Each community forest has an operational plan, which is made with the help of a forest technician in consensus with the users. The plan contains a clearly defined work plan and time schedule. People are not allowed to surpass the prescribed amount of allowable cut in the operational plan, however, they sometimes do. The reason behind this is the high demand of timber and fuelwood and that local people want to create grassland by clearing of the woody vegetation.

Most of the forest users prefer Sal, Asna, Karma, Sissoo, for timber and Bakaino (*Melia azedarach*), Ipil- ipil (*Leucaena leucocephala*), Tanki (*Bauhinia spps*) for fodder, but they prefer to manage their forest for timber and fuelwood. The community forest members have no specific preferences concerning size of timber and cut according to availability and demand of users. A committee for removal of timber has been established during the harvesting time and the committee asks for technical support from the national park. The new forest management introduced by the plan changed a lot in the forests. The forest

area has increased, hunting is stopped and people are aware of conservation and as a result the diversity of their forest has been increased.

Most of the respondents said that the objective of forest management is not only to get forest products. They are also doing it for tourism development and conservation of resources for future generations. Most of them thought that all species have some importance in nature, but they prefer timber species. They said they do not care about wildlife requirement during silvicultural operations, but a few people within the group said that they left some dead trees and planted fruiting trees for birds. They agreed that there was a significant increase in bird populations in their area after the buffer zone community forest program was implemented, due to the increment of forest cover and stop to hunting. They accept that they do not have sufficient forest products in their community forest and they rely on other community forests, buffer zone forests and national park forests for scarce forest products; even though such use of the national park is illegal. The committee penalizes people who collect any forest products from community forest without permission and all studied community forests have appointed guards for patrolling the area.

Relation to the national park

Most of the respondents appreciated to have the national park in the area, because they have a lot of direct and indirect benefit from the park. They thought the area is famous due to the park, they can generate revenue for local development, they get employment, they have a good environment and they enjoy the nature for recreation. They want to conserve wildlife in the national park and in their community forest because they benefit from tourism and they know that if there is no wildlife there is no tourism. A few people in a group interview did not like dangerous wildlife in their community forest. Most of the group members are aware that they get park generated revenue for local development, but some of the women in group interviews were not aware of several aspects of the community forestry program. They were happy with the park since they get several benefits from it, like revenue for local development, thatching grass, reeds and other benefits, but most of them still expect more forest products from the park. Some of them want to conserve the park themselves like they do with the community forest, but all of them accept that if the park was not established most of the biodiversity would be lost.

Suggested changes

People wanted compensation for all losses caused by wild animals. They would like to have electric fences around the settlement to avoid intrusion from animals like elephants and rhinos. They want the grass collection period in the national park to be longer, like it was previously (one week or more, now it is 3 days only). They suggest a rotational grazing system in the community forests. They wish to conserve the buffer zone forest as community forest and have

regular technical support from the park authorities to conserve it. They suggested that programs that increase the awareness of alternative energy sources are necessary for the future development. They want to know more about park management activities, and complained that they never know what is happening inside the park. They expressed that "We should be aware of the park management because this is our park".

Park Managers and service providers (key informant surveys)

Forest Management

Most of the park managers and service providers expressed that in the community forests area community people have mainly removed dead wood (standing and lying), but they also perform thinning, cleaning, grassland management and wetland management activities. In thinning operations people thinned dense areas, they cleaned out unfavourable species of bushes and climbers to allow growth of favoured species, and they cut trees to create open areas for grasslands, constructed artificial water holes and improved natural water sources. Most of the service providers and park managers agreed that the management activities are not intensive. They think Sal, Asna, Karma, Sissoo are the species preferred by the people for timber and fuelwood in the community forest. Sometimes the park authority is not able to provide technical support according to community forests' requirement because of lack of staff in the national park.

Relationships between the park and people

Most of the park managers and service providers believe that the park people relationship has improved a lot after implementation of the buffer zone program, but some of them thought that it has not improved as much as expected, and that there is still room for improvement. A few of them think the awareness level will increase with time, now people want both conservation and utilization of biodiversity, but in the initiation of the program they were reluctant to take responsibility for conservation.

Possible improvement

Most respondents suggested that there should be compensation for any type of wildlife damages, for example human injury, killing of domestic animals and raiding of agricultural crops. They agreed that the awareness level is not equal for all buffer zone people, so there is a need for awareness programs for school children and community people. Some of the service providers realized that the high demand of fuelwood is the reason why it is necessary to provide alternative sources of energy for the community people. Service providers and park personnel emphasized different mechanisms for improvement of the conservation work, like crop insurance policies, fencing, trenching, and other

alternative ways to avoid wildlife damage. A few of the park personnel also indicated that the government revenues should be allocated to wildlife areas and that good planning, participation of people and transparency of community development activities is necessary. They also felt a necessity of amendment concerning some policies and rules for further improvement of the relationship between people and park authorities.

Conservationists and birdwatchers (key informant survey)

Management

Conservationists and bird watchers have mixed responses concerning the impact of present forest management practices on the bird community. Some of them expressed that management might have negative impact on bird diversity, because of removal of dead wood which is important for roosting and nesting birds. Others expressed that the forest management practice might have a positive impact on birds, because the management is not intensive and also include grass cutting and wetland improvement activities, resulting in diverse habitats. Some of them had strong objections against the present pressure from tourism, which might result on detrimental effect on biodiversity particularly in Baghmara community forest. One of the members of the Bird Education Society pointed out that tourism, forest management and breeding season of bird occurs during the same season leading to a negative impact on breeding birds. Most of the conservationists were worried about possible threats due to over-use of pesticides in agriculture, water pollution, overfishing, loss of grassland and wetland and use of diclofenec medicine to cure the domestic animals.

Trends in bird diversity

All respondents replied that that the diversity and abundance of birds has increased in the area, with the exception of vulture populations. However, one of the respondents claimed that the bird diversity of Jankauli and Baghmara community forest has decreased in recent years due to disturbance created by tourism. All respondents agreed that the factors responsible for increases of bird diversity and population sizes were increased forest cover, improved habitat conditions, increased forest area and ceased hunting. A few of the respondents believed that the possible causes for the decline of some bird species are high human disturbance, intensive removal of dead wood, scarcity of animal carcasses, use of diclofenac for domestic cattle and use of pesticides in crop production.

Awareness of conservation - levels and trends

All of the respondents expressed that the awareness of wildlife conservation has increased after implementation of the buffer zone programme and community forest management program. They also agreed that people are

positive towards wildlife conservation and that people are interested in conservation of wildlife in the area, since they get revenue from the park and benefit directly from the tourism. Some of them indicated that people are compelled to steal forest products from the national park and other buffer zone forests because of necessity even though they are aware that it is illegal. A few people stated that local people are not aware of ecological requirements of different species.

Improvement

Most of the conservationists thought that forest management practice is important for both the forest and people. Different conservationists have different suggestions for future improvement. Most of them suggest that alternative sources of energy, awareness programs, restrictions for tourism, habitat improvement (maintenance of grasslands and wetlands in forests) and that consultation with conservationist during forest management operations will improve the situation. Similarly, they wanted to promote plantation of multipurpose tree species, and stated that a proper management of buffer zone forests will further contribute to a positive development.

Bird diversity and responses to different factors

Species diversity

A total of 129 bird species was recorded in all 66 sites. Most of the species were relatively rare, 93 species were recorded at ≤ 10 sites, 36 species occurred at ≥ 10 sites and only 20 species occurred at ≥ 20 sites (Appendix 6). An univariate analysis showed that species diversity in the three forest types (see Fig. 8) did not differ significantly (Kruskall Wallis test, chi-square= 0.08, P≥0.05), the mean number of species per sample plot was 16.9, 17.1 and 18.1 for national park, community forest and buffer forest, respectively. Sal forest (mean species number =16.5) was somewhat less diverse than Riverine forest (mean=18.2), but again this was not statistically significant (Table 3). Among the rare species (occurred ≤ 10 sites) a total of 19 species was found only in national park sites, 12 species were only found in community forest and three species were only found in buffer forest.

The comparison of species diversity between edge and interior showed a significant difference (Table 3) between interior and edges irrespective of forest. Similarly, the diversity in edge and interior was significantly different in community forest and buffer forest, but not in national park sites (Table 3). Within vegetation types Sal forest had significantly different species diversity at the edges and in the forest interior, but in Riverine forest there was no significant difference between forest edges and the forest interior (Table 3).

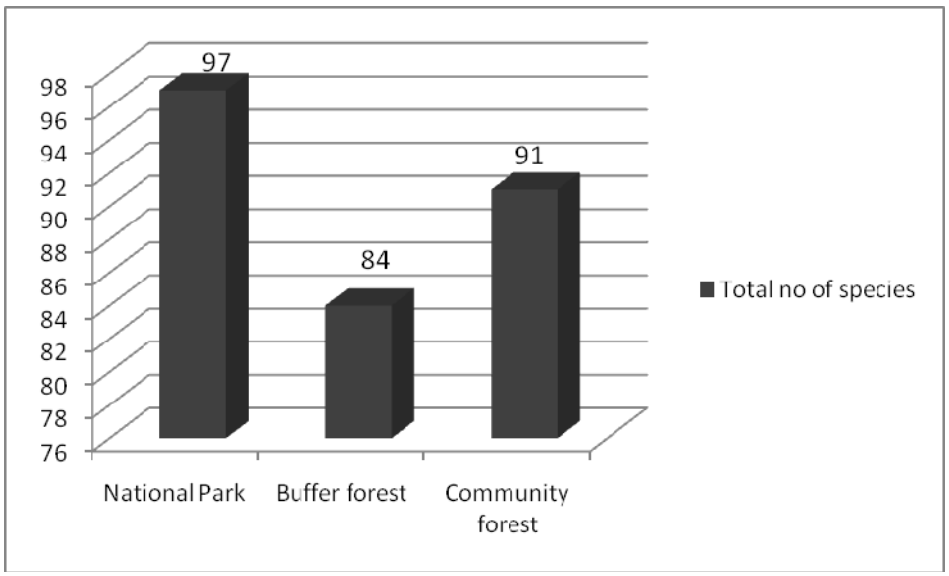

Figure 8. Number of bird species present in national park sites, buffer forests and community forests

Table 3. Comparisons of bird diversity in different forest types, vegetation types, edges and interior, χ2 values and p-values are from Kruskal Wallis tests.

Comparison variables	d.f.	mean species no.	SD	p-value	χ^2
Forest					
National Park	1	16.92	4.27	0.99	0.08
Buffer forest		17.11	4.74		
Community forest		18.13	6.52		
Vegetation Type					
Sal forest	1	16.47	4.29	0.23	1.44
Riverine forest		18.19	5.9		
Interior and Edge					
Edge	1	41.33	5.37	0.006*	7.66
Interior		28.08	4.78		
NP edge	1	17	3.46	0.81	0.06
NP interior		16.87	4.81		
Buffer forest edge	1	20.29	4.5	0.02*	5.14
Buffer forest interior		15.09	3.81		
Community Forest edge	1	20.82	6.74	0.02*	5.28
Community forest interior		15.85	5.61		
Sal forest edge	1	18.44	3.75	0.05*	3.83
Sal forest interior		15.62	4.31		
Riverine forest edge	1	19.89	6.07	0.12	2.47
Riverine forest interior		16.5	5.36		

* statistically significant

Bird species responses to different landscape and habitat variables

A canonical correspondence analysis (CCA) of the 36 most common species (occurring at ≥ 10 sites) showed that the first ordination axis consisted of a gradient from sites far from settlements (often Sal forests with much dead wood) to sites with high degree of human disturbance and grazing (often Riverine forest), see Fig. 9. Bird species typical for the undisturbed sites were *Psittacula eupatria, Megalaima lineata, Pellorneum ruficeps, Psittacula krameri, Coracina macei* whereas typical species for the disturbed sites were *Gallus gallus, Lanius schach, Dicrurus macrocercus*. The second ordination axis consisted of a gradient in distance to wetlands and/or forest types (National Parks and/or Community Forest). The national park found closer to wetland sites and buffer zone community forest sites found far from that. Typical species for the "dry" buffer zone community forests were *Dendrocopos macei, Aegithina tiphia, Dendrocopos canicapillus, Gaucidium raiatum, Sitta frontalis, Cyornis poliogenys,* while few of the analysed species showed strong affiliation to wet forest sites.

The CCA showed that several habitat variables and species were associated with a management gradient (third ordination axis) and a vegetation type gradient (fourth ordination axis), which therefore also are presented (Fig. 10). The third ordination axis consisted of a gradient from sites consisting of buffer zone community forest with more intensive forest management practices situated near settlements to sites far from settlement with no forest management practice (mainly national park sites). Representative bird species of managed forest sites were *Corvus macrorhynchos*, *Coracina macei*, *Dicrurus hottentottus*, *Sitta castanea*, *Ficedula parva* and *Megalaima lineate*. Species which avoided sites with forest management practice and preferred national park sites far from settlements *were Zosterops palpebrosus, Aegithina tiphia, Pellorneum ruficeps and Copsychus malabaricu*s. Along the management gradient *Dendrocopos m*acei, *Dinopum shorii, Dendrocitta vagabunda, Stigmatopelia chinensis* had also strong association to managed forest, but they were more associated with tree diameter (of dominant trees) than forest management practices.

The vegetation type gradient (fourth axis) consisted of a gradient from Sal forest to Riverine forests, mainly buffer forests. Sal forest had more saplings and a higher crown cover than Riverine forests. Representative bird species for Sal forest were *Prinia hodgsoni, Sitta frontalis,* Turdoides *striata, Parus major and Dicrurus caerulescens* and they also preferred large forest areas to forested sites adjacent to grasslands or wetlands. Typical species for buffer forest were *Gallus gallus, Lanius schach, Psittacula krameri and Acridotheres fuscus.*

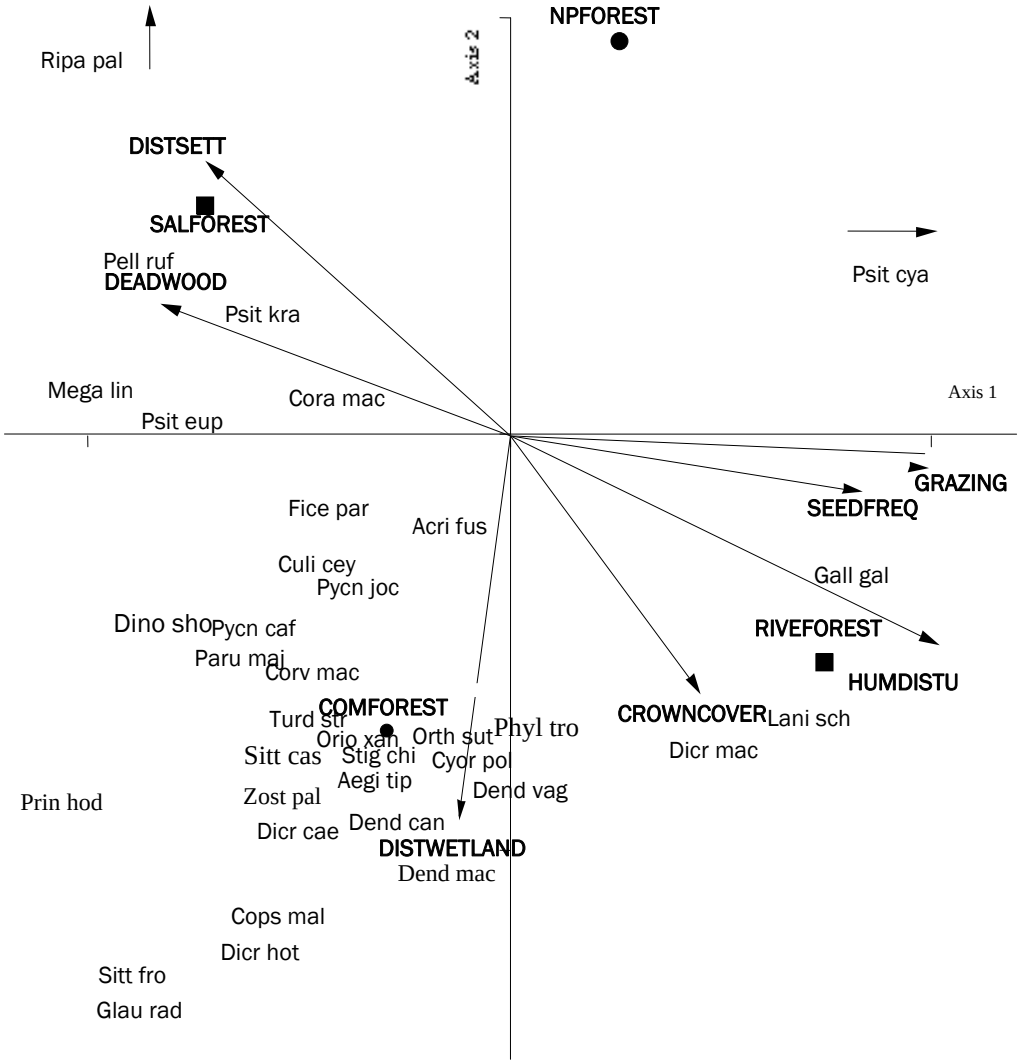

Figure 9. Species-environmental variable biplot from a canonical correspondence analysis (CCA). Species are represented by abbreviations of Latin names (see Appendix 6). For abbreviations of environmental variables, see Table 1. The first axis (F=8.1, P=0.0006), and all four axis in the CCA (F=2.7, P=0.0002) were significantly associated with the abundance of the analysed species. Only habitat variables significant at the P< 0.05 level and with correlation ≥ 0.3 to axis 1 or axis 2 are shown.

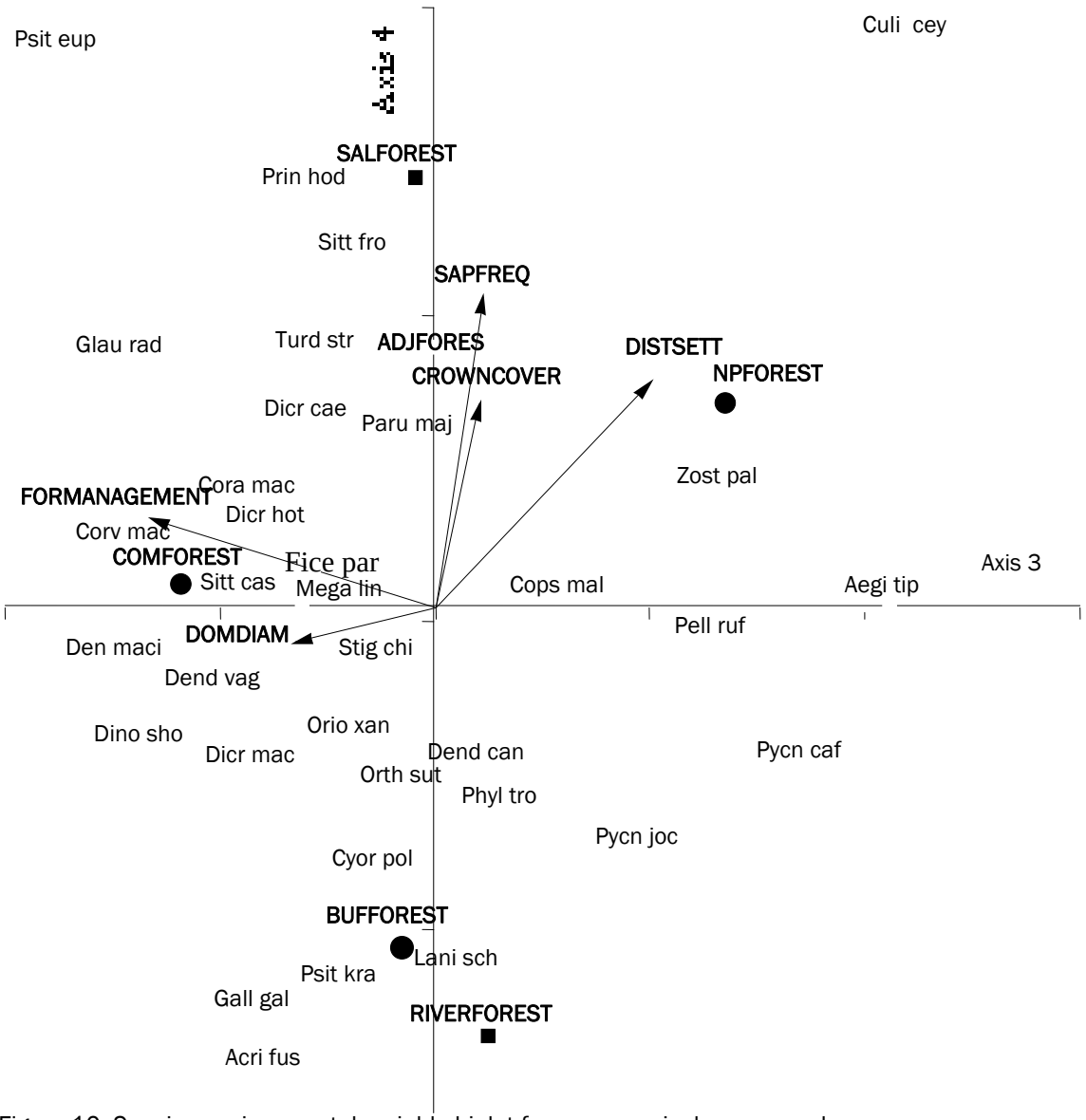

Figure 10. Species-environmental variable biplot from a canonical correspondence analysis (CCA). The first axis (F=8.1, P=0.0006), and all four axis in the CCA (F=2.7, P=0.0002) were significantly associated with the abundance of the analysed species. Species are represented by abbreviations of Latin names (see Appendix 6). For abbreviations of environmental variables, see Table 1. Only habitat variables significant at the P< 0.05 level and the correlation ≥0.3 to axis 3 or axis 4 are shown.

Thus, the ordination analysis showed that there were large effect of both forest type (National Park, buffer forest and community forest), vegetation type (Sal forest or Riverine forest), forest structure (crown cover and amount of dead wood) and human disturbance (distance to settlements, forest management practice and grazing). The position of the sample plots (which indicates habitat

and landscape composition of the plots) along disturbance gradient (axis 1) and wetland gradient (axis 2) overlapped strongly both for vegetation types and forest types (not illustrated in Figures). However, vegetation types were separated along the vegetation type gradient (axis 4), although with overlap (Fig. 11). Similarly, the three forest types could be separated to some degree along the vegetation type gradient (axis 4, see Fig. 12), although community forests and buffer forests overlapped to a large degree.

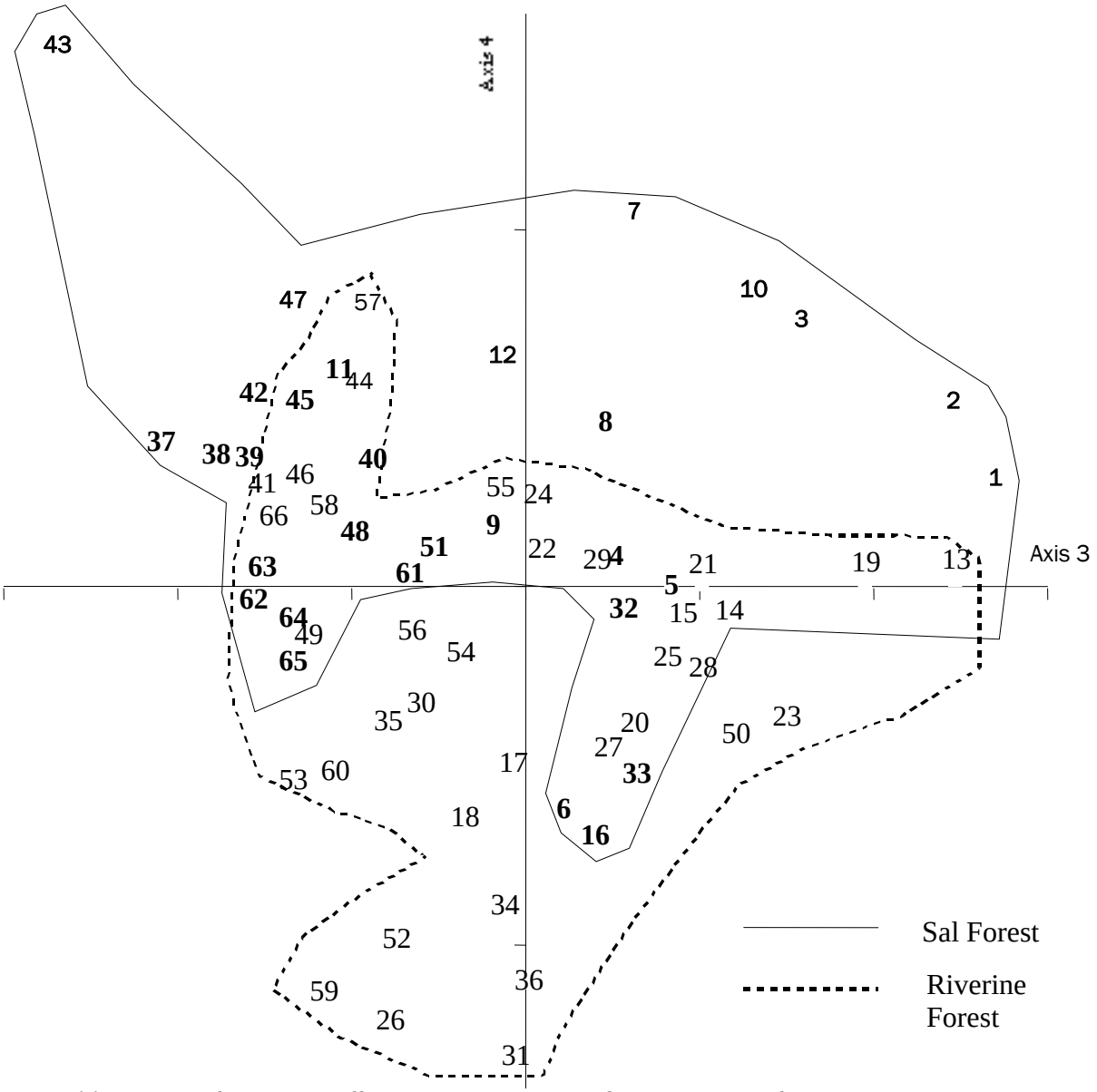

Figure 11. Position of sites with different vegetation types (Sal and Riverine forest) along environmental the management gradient (third ordination axis) and the vegetation type gradient (fourth ordination axis).

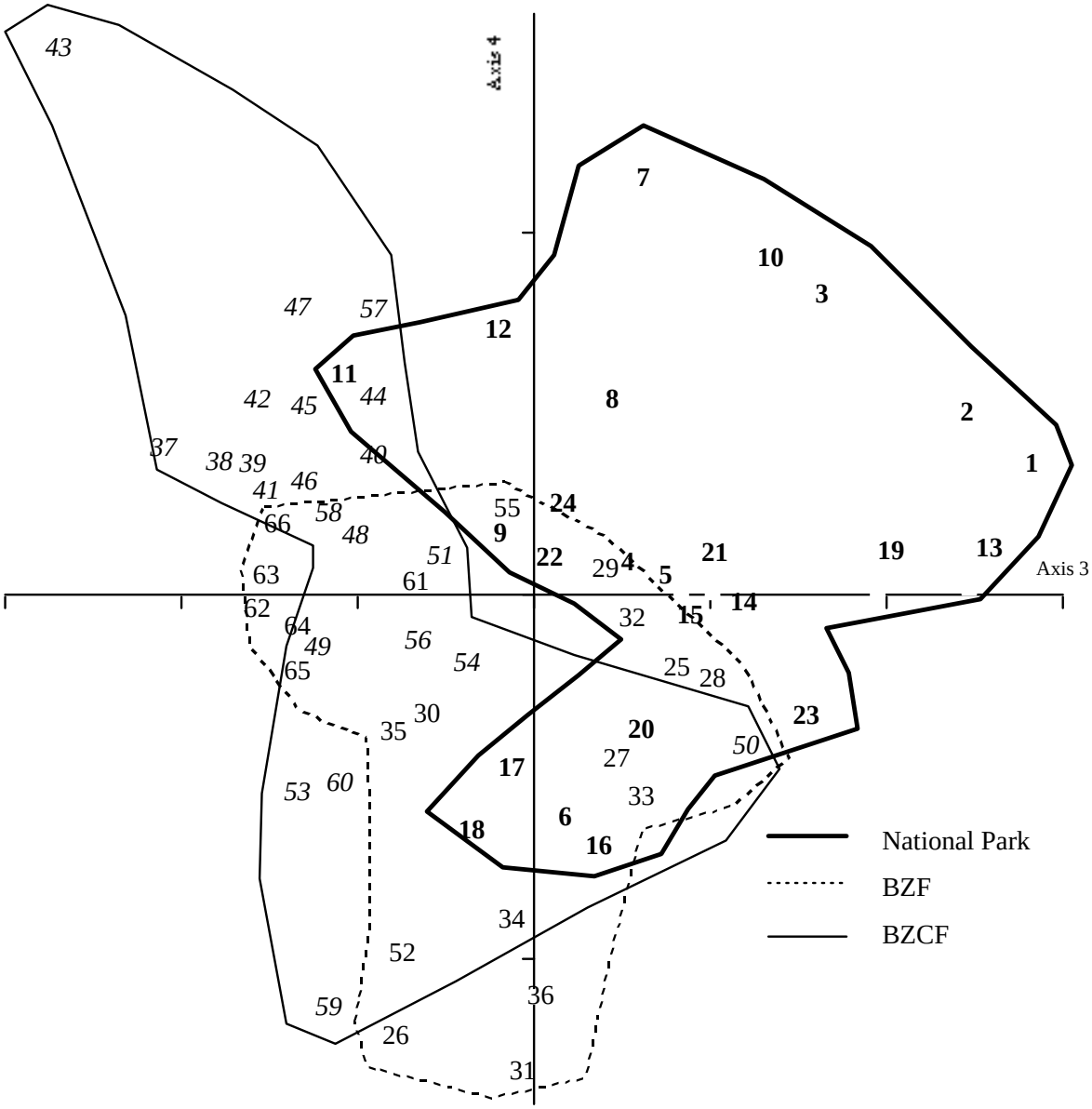

Figure 12. Position of sites with different forest types (National park, buffer forest and community forests along the management gradient (third ordination axis) and the vegetation type gradient (fourth ordination axis).

The CCA analysis focused on relatively common species (analysed species occurred in ≥ 10 sites). Most species were uncommon and therefore analyses of species richness in relation to habitat variables were also performed. These

analyses were performed with stepwise Poisson regressions using species richness of different subgroups (based on major habitats and main food types) as dependent variables and the four environmental axes from the CCA analysis as independent variables. In the analysis focusing on main habitats all birds were classified as forest species, open habitat species, edge species, wetland species or species associated with settlement (Appendix 6). Species richness of forest species showed a strong negative association with the disturbance gradient (first axis) whereas species richness of open habitat species showed a positive correlation with the same gradient (Table 4). None of other groups showed significant associations with this axis. The wetland species showed strong positive association with the wetland gradient (second axis) but not to any of the other axis. Species richness of forest birds showed a negative association with forest management practices and community forests (third axis). In contrast, species associated with settlements and wetland showed positive associations with these factors. Species richness of the same group was negatively associated with the forest type gradient (axis 4), i.e. they were positively associated with Riverine forests and Buffer Zone Forests.

Bird categories with different main food types showed different associations with the four environmental axes. Raptors showed a strong positive association with the disturbance gradient (axis 1), while no other group was significantly associated with this gradient. Only species richness of frugivores showed a positive association with the wetland gradient (axis 2). Species richness of raptors and piscivores were associated with managed forests (axis 3), mainly community forests, while insectivore species were avoided the managed forest areas. Species richness of omnivores, raptors and piscivores showed negative association with the Sal forest (axis 4) whereas insectivores showed the opposite pattern (Table 4).

The total abundance of all species was positively associated to axis 1-3 (Table 4). Thus, sites close to settlements with more human disturbance (axis one), close to wetlands (axis two) and Sal forests with dense crow cover (axis three) were the sites with the highest abundance of bird

Table 4. Associations (from Poission regression with backward selection of variables) between species richness of birds with different main habitat categories, main food categories (see Appendix 6) and the total abundance of birds with environmental axis 1-4 in CCA analyses. (+)/(-) = p<0.1, +/- = p<0.05, ++/--=p<0.01 and +++/--- = p<0.001.

Group	Axis 1 Disturbance gradient	Axis 2 Wetland gradient	Axis 3 Management gradient	Axis 4 Forest type
Forest species	--		+++	
Edge species				
Open habitat species	(+)			
Settlement species			---	--
Wetland species		++	-	---
Insectivores			+	+
Omnivores				---
Piscivores			---	-
Raptors	+++		---	---
Frugivores		+		
Total abundance	+++	+++	+++	

Discussion

Comparison of bird fauna in the national park, community forests and buffer forests

The univariate analysis showed that bird diversity among the three forest types did not differ significantly, but the overall species number was different in the national park (97 species), buffer forest (84 species) and community forest (91 species). The lower species number in buffer forest might be an effect of sampling, since fewer buffer forest sites (18 plots) than national park (24 plots) and community forest sites (24 plots) were sampled. The bird community composition overlapped between all three forest types, but the National Park differed relatively much from the other two site types (Fig. 10 & 11). Rare species were mostly found in the national park, including two globally threatened species (*Leptoptilos javanicus and Prinia cinereocapilla*). In contrast, van Eeden et al. (2006) found that the communal land had more indicator species and significantly higher species richness than the park in a study in South Africa. There are multiple factors affecting diversity and community composition of bird which are discussed in next chapters.

Effect of landscape and habitat structure on bird community

The first axis in the CCA analysis consisted of a disturbance gradient negatively associated with distance to settlement and positively associated with human disturbance and grazing. A few relatively common species; e.g. *Dicrurus macrocercus* (settlement species), *Lanius schach* (open area species) and *Gallus gallus* (forest species) were positively associated to this gradient. Furthermore, the total abundance of birds, and species-richness of raptors, was positively associated to this gradient. In contrast, most species were negatively associated to this gradient, i.e. species-richness of forest species was negatively associated to this gradient (Fig. 8 and Table 4). Sahabuddin & Kumar (2006) found no significant difference in the number of birds recorded between disturbed and undisturbed sites in tropical dry forest, but found lower diversity of birds in disturbed sites and the bird community composition was also different. The avoidance of disturbed sites might be avoidance due to direct disturbance caused by the domestic animals, cattle and humans (Burger & Gochfeld 1998), or by changes in habitat structure due to disturbance. Jotikapukkana (2007) showed that abundance of several deer species in a buffer zone system in a national park in Thailand was negatively associated with occurrence of domestic cattle, which was common in the buffer zone up to 2 km from settlements.

However, for birds (especially canopy species) other factors than competition or disturbance from cattle and shephards might be the mechanisms behind the avoidance of disturbed sites. Differences in forest composition (Chettri 2000 cited in Chettri et al. 2001; Shankar Raman & Sukumar 2002), or vegetation structure due to different management (Shahabuddin & Kumar 2006; Shankar Raman & Sukumar 2002), might affect availability of nest sites and food availability (Thiollay 1997). Canopy cover is important for tropical birds because most of them depend on the canopy for nesting and foraging (Thinh 2006). Baral & Inskipp (2005) argued that parts of the area in and around the park suffer from the disturbances caused by the tourist elephant rides. From group discussions and interviews I concluded that there was no direct harm made by the people because they are aware of conservation and the hunting of birds has ceased. The school children have also received some conservation education in the Buffer zone area since some local and national level organizations have been working with bird conservation (for example the Bird Education Society-based in Baghmara community forest, the National Trust for Nature Conservation, and Bird Conservation Nepal).

Raptors were positively associated with the disturbance gradient (axis 1) in my study; a possible explanation is that many species are adapted to find their prey at the edges or in disturbed and grazed areas with domestic animals. Another reason is that they might be more visible in open areas (disturbed sites) than undisturbed sites due to vegetation structure. Laiolo & Rolando (2005) showed that plots at the edge of pastures had the greatest diversity, but were avoided by some forest specialists. Edges have been shown to have a high rate of predation (Gates & Gysel 1978). Peake & Ritchison (1998) argued that the high edge predation rate might force some species to shift their nest towards places having sufficient cover to hide the nest to avoid predation. Several studies (Baldi 1996; Laiolo & Rolando 2005; Pattanavibool et al. 2004) have found differences in species composition between edges and interior habitat, and structural changes in vegetation is a probable cause for differences in bird diversity and abundance in forest interior and different edge types (Whittaker & Montevecchi 1997). In my study distance to edge was not significantly associated with bird community composition (Fig. 8 & 9), although species richness of some groups (settlement species and open habitat species) was significantly correlated with this factor in the univariate test (Spearman rank correlation, both $p<0.05$). The overall effect of the disturbance gradient (axis 1 in the CCA) in the ecotone between forest and settlements was stronger than the edge effect and probably occurred at larger distances from the edge (distance to settlement varied between 50 m and 12 km).

The second axis in the CCA consisted of a wetness gradient (distance to wetland) and forest types (with National parks closer to wetlands and community forests at a distance from wetlands). However along the wetland

gradient most of the common species showed strong affiliation to community forests (distantly located from wetland sites and with more crown cover) and few species (e.g. *Riparia paludicola)* preferred wet areas (Fig. 8). As expected species-richness of wetland birds was positively associated with this gradient, but also species-richness of frugivores (Table 4), i.e. they preferred national park sites close to wetland, and avoided community forest sites. In the case of frugivores there might be a high availability of fruiting trees (or fruits) in the wetter areas in the undisturbed national park forests, although the restricted data (occurrence and absence of fruiting trees at a small plot scale) and statistical analyses in my study could not support this. Community forests were generally found at longer distances from wetlands than the national park sites. However, the survey focused on forest bird species and among them most were residential species and a few migratory species. Many of the migratory species had not arrived during the research period and this might have affected the results, since 20 percent of the migratory birds are wetland species (Khadka, 2005). The key informant survey showed that over-fishing, human disturbances, cattle grazing, illegal hunting, and increased use of pesticides in agricultural crops are considered as major threats to the birds in the area. Baral & Inskipp (2005) also identified similar threats to wetland birds in the area.

I found that there were strong effects also of landscape variables (distance to settlements, human disturbance, grazing) that all reflect location of the study plot in the landscape. Some studies have shown that the avian community composition was more closely related to stand level variables than to landscape variables Sallabanks et al. (2006). When taking position in the landscape into account habitat structure and management had strong effects on bird community composition. A majority of the species (e.g. forest species) avoided human settlements (Fig. 8), and were largely influenced by forest habitat and forest management (Fig. 9, Table 4). Among the analysed habitat variables type of forest (National Park, community forest or buffer forest), forest vegetation type (Sal forest or Riverine forest), forest management practice, sapling frequency, seedling frequency, area adjoined to forest, crown cover, diameter of trees and amount of dead wood were all correlated to different environmental axes in the CCA.

Forest bird species-richness (rare species made up a large proportion of the species) and the total abundance of birds was negatively associated with management intensity (Table 4), i.e. many forest species avoided the managed forest, which had less crown cover and large more scattered trees. In contrast, the CCA analyses of the more common species (Fig. 9) suggested that several of these were positively related to forest management practices. Also other studies have suggested that canopy cover influence overall species richness and number of forest dependent species (Owino et al. 2008). The extraction of timber and fuelwood, which occurred in some community forest change the

structure of forest, and that seemed to have effects on the forest bird community. The structural change of vegetation due to extraction of forest biomass has been shown to cause significant effects on forest structure (Sapkota et al. 2009) bird diversity and species composition (Shahabuddin & Kumar 2006), although there are contradicting results concerning effects of logging (thinning, cleaning etc.), perhaps due to the intensity of the management. Chettri et al. (2001) found no difference in diversity and abundance of bird species between utilized and unutilized forest in Himalaya. Similarly, Wunderle et al. (2006) did not find significant differences in species diversity between control sites and cut forests. However, a study in Sri Lanka found that endemic bird species couldn't tolerate logging, while other species were less affected (Wijesinghe & Brooke 2005). Laiolo (2003) also found that the forest bird density and diversity in the Nepalese alpine region were significantly lower in intensively utilized forest than in unutilized forest. Cleary et al. (2007) found that insectivores in general avoided logged areas, but that undergrowth insectivores preferred the same logged areas. Thus, relatively rare species, possibly with specific habitat requirements and/or endemic species seem to be more affected by forest management practices than more abundant forest generalists, such as some insectivores. The tourism season, forest management and the breeding season of birds coincide during same season, so some sensitive species might avoid the managed areas and more disturbed sites and prefer the undisturbed national park sites.

The management intensity of community forest was not high; at most the amount prescribed by the operational plan was cut on a rotational basis, but in buffer forests the absence of operational plans and illegal extraction might be detrimental. Community forest and buffer forest consisted of more large trees than national park sites; i.e. mature trees were not cut in buffer zones, and small sized timber and/or dead wood was the main forest products used, especially in Sal forest. Nagendra et al. (2005) also found that community managed forests consisted of significantly taller trees, although a few species was dominant, than protected areas. The local people used more Sal, Sissoo, Asna, Karma, Khair for timber and fuel-wood than they used Riverine species like Veller. Panta et al. (2008) also mentioned that the Riverine forest dominated by Veller, was less useful than Sal forests, and remained untouched. In the midhill community forests in Nepal, Sal forest harboured more bird species than the other forest types however, in some community forests in the same region other species than Sal are cut for fuelwood, which might have negative effects on bird diversity (Basnet 2007).

According to focus group discussions the community people were not able to fulfil all needs for forest products in community forests and illegal cutting and use of other forest products from the national park and buffer forest occurred regularly (see also Straede et al. 2002; Straede & Treue 2006). Since the

protection of national park is strict, the unauthorized extraction is especially high in buffer forest (Nagendra et al. 2008). However, the result revealed that people want to grow multipurpose tree species in their community forest to fulfil all their forest products needs. As a result, they already initiated plantation of several indigenous plant species and in many cases natural regeneration was re-established. People prefer timber and fuelwood trees in their forests and remove bushes, climbers and invasive species to benefit selected species, and they also manage grasslands and water sources available for domestic animals and wildlife. An overall forest management objective was not only to fulfil the need for forest products but also to promote wildlife tourism in the community forests. People try to follow the operational plan and expect to get forest products from the national park and buffer forest and other alternatives like biogas plants. They want to get forest products from the national parks legally; however this is restricted by the National Parks and Wildlife conservation Act (1973), although some non timber forest products are legally available (Straede & Helles 2000).

The forest management history of the area showed that the forests have been under high human pressure and the condition of forests was highly degraded. The forest degradation was high during the period 1976-1989 (Panta et al. 2008), and during that time no community initiatives were started. Most of the forest areas in Terai handed over to communities had lower plant biodiversity and tree density than those retained as national forest (Nagendra et al. 2005). After community conservation started (plantation and protection according to community forest operational plans) the degradation rate was retarded during the period 1989 - 2001 (Panta et al. 2008). The synthesis from the group interviews and key informant survey with different community people, conservationists and birdwatchers suggested that the diversity and abundance of bird species have increased after initiation of the community forestry program, because of establishment of natural regeneration and improved forest condition. Some vulture species have declined due to diclofenac poisoning (Baral & Inskipp 2004). Nagendra et al. (2008) also found that community forest groups and other community-based organizations around the Chitwan national park were capable to slow down the deforestation and forest fragmentation rate after the initiation of buffer zone program.

Perception and attitude of local people towards wildlife

This study showed that people were positive towards the National Park as it provided opportunities for tourism industry, recreation, revenue for local development and some forest products. Furthermore, people were happy because the park is a major source of income and the area is renowned in the world due to the park, and the biodiversity has been conserved due to establishment of the park. People have a kind of ownership feeling towards the

park and community forest. Similar results are presented by Bauer (2003) from a national park in Cameroon. He noticed that the attitude of local people was positive and motivated by benefits from the park, as well as the intrinsic value of the park. Due to conservation programs in the local community people were aware of conservation and they managed their community forest both for domestic animals and wildlife, since tourism is a major source of income for people. A study in an Indonesian national park found that people had positive attitudes and a strong support for conservation regardless of tourism benefits (Walpole & Goodwin 2001). My study also confirmed that it is important to include the local people in the park planning process because people were eager to know about the park management activities. In contrast, a study carried out in Bhutan showed that more than fifty percent of the people disliked the national park because of animal depredation, crop damages, and lack of compensation. In this case, the farmers were excluded from the park planning process (Wang et al. 2006). Wang et al. (2006) found that the attitude of people was related to age and literacy of the respondents, livestock holding and landholding. In a biosphere reserve in India people were not satisfied with the present benefit sharing mechanism and community support programs (Maikhuri et al. 2001).

The respondents in my study were involved in the Buffer Zone management program, confined in tourism development and they got some benefit from the park. The major causes of conflicts between park and people in Chitwan national park concerned grazing in the park, illegal hunting and fishing, crop damage and threat to humans and domestic animals by wild animals from the park (Nepal & Weber 1995). People were unhappy with the restrictions imposed by the park and damage caused by the wildlife, but happy with use of resources (legally and illegally), environmental and recreational services (Allendorf et al. 2007). In my study, conservationist and service providers were optimistic concerning conservation of the national park provided that the government could compensate for damages, involve the local people more in park planning process and give different alternatives for local people. There have been some measures to compensate the people for different kinds of wildlife damages in the Chitwan area, but it has been considered to be unsuccessful (Nepal and Weber 1995), and it has also been argued that compensation is not the only solution to changes in the attitude of the people (Arjunam et al. 2005). Buffer zone people say they need more resources from the park, and want legal access to them since there are no alternatives. On the other hand, they also know that if there had free access to forest resources people would finish these resources (Allendorf et al. 2007). A study carried out in the same area of Nepal suggested that the conflict between park administration and people was not solved; it was temporarily postponed (Hjortso et al. 2006).

Conclusions

This study showed that there were large effects of a disturbance gradient (human disturbance, distance to settlements and grazing) on the bird community composition. A few abundant bird species and the total abundance of birds were positively associated to this gradient. In contrast, most bird species were negatively associated to this gradient, i.e. species-richness of forest species was negatively associated to this gradient. Thus, there is some "conflict" between conservation of forest bird species and human use of the buffer zone forests. This was also illustrated by the negative effects of forest management on forest bird species-richness (which made up a large proportion of the species), i.e. many forest species avoided the managed forests. In contrast, analyses of the more common species suggested that several of these were positively related to forest management practices. Thus, the possibilities for conservation of birds in buffer zone forest are good for common species, and especially for species associated with settlements and wetlands. However, also forest birds were found in community forest and buffer forest sites, although rare species seem to be more abundant in national park sites.

Buffer zones serve the dual purpose of 'extension buffering' (offer habitat for common bird species) and "socio-buffering" by providing goods for local people. Thus, the gradient in biological values (related to distance from settlements); from intensively managed sites to protected national parks is a natural part of buffer zone systems.

Effects of different management regimes are not known in detail but we know that some species prefer unmanaged areas. However different bird species react differently to different management operations. Since community forests were almost in degraded condition before community forest management activities, the local community seems to be able to conserve both forest habitats and bird diversity in the area.

People are aware of the need for conservation, but they do not have sufficient knowledge about the requirements of different species in that area. People managed their community forest both for domestic animals and wildlife, since tourism is a major source of income for them. They want to conserve the forest with a holistic approach although they have a preference for some specific timber species. However, the forest handed over to the community was degraded and the community was able to increase the forest cover by plantation and management. Moreover, the populations of birds seem to have increased during this period despite that the buffer forest is under pressure.

The conflicts between park and people have decreased since the initiation of buffer zone management program, but they is still exist. The major conflicts between park and people in Chitwan national park concern resource use, wildlife damages and threat to human and domestic animal by wild animals from the park. People were unhappy with the exclusion of local people in park planning process. There is still room for improvement of in the park people relationship, since the management goal of local people and the park authorities since they both want forest products for local people and conservation of biodiversity.

Recommendations

Participation of local people in park planning processes and a dialogue is necessary to address the conservation and utilization aspects of biodiversity. The diverse, and possibly conflicting, perceptions that people have toward protected areas should be recognized and understood. Changing people's attitudes by addressing their needs and aspirations may be one of the best ways to improve the park–people relationship for long term conservation.

Management should work to meet people's extraction needs if possible, but also take advantage of and strengthen people's understanding of the importance of conservation of the area. Alternative energy sources like biogas will further help to address the scarcity of energy. To involve biodiversity experts in the community forest management process would also improve the situation. Leaving some dead tree and removing some living trees might have a positive impact on some forest bird species. Disturbances from tourist can be avoided by creating awareness and limiting the number of tourists in the area.

Furthermore, more research is necessary to know the effect of different forest management practices on the bird community. The community forests are managed by the community and the national park is managed by the government. These two management systems functions rather well but there is a need to improve management of buffer zone forest where there is sometimes areas with an open access situation to resources. If managed properly, that will compensate the forest products needs of local people.

Acknowledgement

I would like to express my sincere gratitude to my supervisors Åke Berg and Susanne von Walter, Swedish Biodiversity Centre for their help, stimulating suggestions and encouragement throughout my research. I am grateful to my field supervisors Hem Sagar Baral and Indra Prasad Sapkota for their guidance and support during my research. I would like to pass special thanks to Malin Almstedt, Director of Studies and Torbjörn Ebenhard, Acting Director of Swedish Biodiversity Centre, for their suggestions during the analysis. I am also grateful to Per Alström for his valuable suggestions and guidance especially on nomenclature for the birds.

I am deeply indebted to my field assistants Basu Bidari - Founder Member of Bird Education (BES), Hem Subedi - Chairman of BES and Kapil Pokhrel- Biodiversity Conservation Centre, Chitwan for their hard working throughout the bird survey. I would like to give my thanks to Dineshowr Mahato, Ananath Baral, Nageswor Thakur, Ishwori Mahato and staff of Chitwan national park for providing me the necessary support and arrangement during my field work.

I want to acknowledge Ram Chandra Nepal (Project Manager, Biodiversity Conservation Center, Chitwan) for giving me logistic support during my fieldwork. Many thanks to the staff of the Biodiversity Conservation Centre, especially Tam Lal Pandey and Harka Man Tamang for their care and support during my Chitwan stay. Similarly, I am obliged to "Karnali Kali" and two other elephants for their security support during work inside the national park.

I am also pleased to my class friends specially Ivan, Jelena, Johanna, and Rashid for their support during my study. I am grateful to my mother in law Mohan Kumari Bhattarai, my son Subigya and husband Babu Ram and other family members for their regular encouragement and support throughout my research.

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Appendix 1 Bird survey protocol

Name of community forest: Plot No. G.P.S Point:
Observer: Observer: Observer:
Date/time: Date /time: Date/time:

SN	Species	No. of birds 50m radius					
		inside			outside		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
27							
18							
19							
20							
21							
22							
23							
24							
25							
26							

Appendix 2 Habitat survey protocol

Name of Forest: Plot No. GPS Point
Date..... Type of Plot.....
Surveyor.....

Distance from	Management application/disturbances
Forest edge	Silvicultural practice.....
National Park	Grazing Heavy□ Medium □ Low□
Settlement	Human disturbance Extreme □ Heavy □ Medium □ Low □
Road	
Wetlands	Fire Yearly□ Sometimes□ Never□

Percentage Cr. Cover Percentage Gr. Cover
Pole Frequency Dominant spps
Sapling frequency Dominant spps
Regeneration Frequency Dominant spps

Tree species frequency

Species	Number of tree
1	
2	
3	
4	
5	
6	
7	
8	

Age of forest Stand Years	Adjacent area
Sapling Pole Matured	Wetland
Diameter of dominant tree	Arable field
Fruiting tree	Pasture
Dead Wood	Settlement
Any special feature of the sample plot	Forest area

Appendix 3 Checklist for interviews and surveys

Checklist for group interviews and key informant survey (Community Forest and buffer zone management committee members)

What are the present Forest Management Practices performing in your Community Forest?
Which species you prefer for wood?
What type of tree will you cut?
How do you decide which tree you will cut? If there any training or technical assistance?
What is the objective of your BZCF Management?
Do you think is it necessary to conserve all species found in your forest?
Did you find any difference in bird community after some decades for example after managed by the community? Do you know the reason?
Do you think about the bird species while cutting the tree?
How do you determine when you perform any management activtity in Your BZCF?
How do you determine how much amount of forest product you removed?
Do you like National Park here? Why?
Do you like to conserve wildlife /birds in National Park? Why?
Do you also prefer wildlife in your BZCF? Why?
Do you have suffcient forest products in your BZCF?
Is there any illegal activities in your BZCF?If yes, how do you controll?
What types of benefts are you getting from the National Park?
Are you satisfied with the benefit granted from the Park?
If there was no national Park what will be the consequences?
Suggestions on how to change management in order to reconcile the management goal.

Appendix 4 Questions for interview- Conservationist and Bird Watchers

Can you tell about trend of bird diversity is it increased or decreased?
What is the reason?
What is the level of people awareness?
The forest management and habitat management is appropriate in terms bird (wildlife) conservation?
Do you have experience any serious therats for the bird conservation or overall conservation?
How can we reconcile the conservation and management goals?
Do people interested for conservation?
What is your recommendation for future conservation? And management of Community Forest, Buffer Zone Forest and National Park?

Appendix 5 Question for interview-Park managers and service providers

What are the forest management practices performing by the BZCF?
Which species they preferred for different purpose?
Which size of tree they preferred to cut? How they decide?
What is the objective of community forest management, Buffer Zone Forest?
Do they think all the species equally important for conservation?
Do they think about the requirement of different species which performing the management activities?
Do they like to conserve wildlife in their BZCF?
Are they satisfied from the benefit granted from the park?
What do you think is there any improvement between park and people?
How can we reconcile the goal of conservation and management? How can both people and conservationist become satisfied?
After BZCF is there any improvement in habitat and wildlife in the BZCF?
What do you feel is there still necessary for good relationship and long term conservation?

Appendix 6 Number of birds by Forest Types

Number of sites, estimated number of individuals and mean number of individuals in different forest for all species observed at total 66 plots.

Species	Type	Food	No. sites	No. individuals	NPforest	BZForest	BZCForest
Gallus gallus	*FO*	*OM*	11	18	0.08	0.28	0.17
Pavo cristatus	*FO*	*OM*	7	41	0.04	0.06	0.21
Tadorna ferruginea	*WT*	*OM*	4	8	0	0.11	0.08
Anastomus oscitans	*WT*	*PI*	2	3	0	0.06	0.04
Ciconia episcopus	*WT*	*PI*	1	1	0	0	0.04
Leptoptilos javanicus	*WT*	*PI*	5	11	0.08	0.06	0.08
Pseudibis papillosa	*WT*	*PI*	2	6	0	0	0.08
Ardeola grayii	*WT*	*PI*	5	18	0.04	0	0.17
Bubulcus coromandus	*OP*	*IN*	3	5	0	0	0.13
Ardea cinerea	*WT*	*PI*	1	1	0	0.06	0
Egretta garzetta	*WT*	*PI*	3	8	0	0	0.13
Phalacrocorax carbo	*WT*	*PI*	1	3	0.04	0	0
Anhinga melanogaster	*WT*	*PI*	1	2	0	0.06	0
Pernis ptilorhyncus	*FO*	*RA*	6	10	0.13	0.06	0.08
Milvus migrans	*ST*	*RA*	1	1	0.04	0	0
Spilornis cheela	*FO*	*RA*	6	6	0.04	0.06	0.17
Circus cyaneus	*OP*	*RA*	1	1	0	0	0.04
Accipiter badius	*FO*	*RA*	3	3	0.04	0	0.08
Spizaetus cirrhatus	*FO*	*RA*	1	1	0.04	0	0
Microhierax caerulescens	*FE*	*IN*	5	10	0.08	0.06	0.08
Falco tinnunculus	*OP*	*RA*	2	2	0	0.06	0.04
Vanellus indicus	*WT*	*IN*	2	4	0.08	0	0
Streptopelia decaocto	*OP*	*FR*	5	9	0.17	0	0.04
Streptopelia orientalis	*OP*	*FR*	1	2	0.04	0	0
Stigmatopelia chinensis	*FO*	*FR*	38	72	0.46	0.61	0.67
Chalcophaps indica	*FO*	*FR*	6	8	0.08	0.11	0.08
Treron bicinctus	*FO*	*FR*	1	10	0.04	0	0
Treron pompadora	*FO*	*FR*	1	2	0.04	0	0
Treron phoenicopterus	*FO*	*FR*	5	25	0.17	0.06	0
Psittacula eupatria	*FO*	*FR*	25	87	0.38	0.06	0.63
Psittacula krameri	*FO*	*FR*	44	278	0.63	0.61	0.75
Psittacula cyanocephala	*FO*	*FR*	19	190	0.38	0.39	0.13
Psittacula alexandri	*FO*	*FR*	4	6	0.04	0.06	0.08

Continue

Appendix continued

Species	Type	Food	No. sites	No. individuals	NPforest	BZForest	BZCForest
Centropus sinensis	*OP*	*IN*	7	7	0.08	0.06	0.17
Centropus bengalensis	*OP*	*IN*	1	1	0	0	0.04
Phaenicophaeus tristis	*FO*	*IN*	4	4	0.17	0	0
Hierococcyx varius	*FO*	*IN*	1	1	0	0.06	0
Ketupa zeylonensis	*FO*	*PI*	1	1	0	0	0.04
Glaucidium radiatum	*FO*	*IN*	12	14	0.08	0.06	0.38
Athene brama	*ST*	*RA*	4	4	0	0.06	0.13
Hemiprocne coronata	*FO*	*IN*	1	3	0	0.06	0
Coracias benghalensis	*ST*	*IN*	1	1	0	0	0.04
Eurystomus orientalis	*FO*	*IN*	3	3	0.08	0	0.04
Pelargopsis capensis	*WT*	*PI*	4	4	0	0.11	0.08
Halcyon smyrnensis	*WT*	*PI*	6	9	0	0.17	0.13
Alcedo atthis	*WT*	*PI*	1	1	0	0.06	0
Nyctyornis athertoni	*FO*	*IN*	7	8	0.17	0.17	0
Merops orientalis	*OP*	*IN*	5	13	0.04	0	0.17
Merops leschenaulti	*FO*	*IN*	7	18	0.13	0.06	0.13
Upupa epops	*OP*	*IN*	1	2	0	0.06	0
Anthracoceros albirostris	*FO*	*FR*	9	20	0.08	0.22	0.13
Megalaima lineata	*FO*	*FR*	18	32	0.29	0.17	0.33
Megalaima haemacephala	*OP*	*FR*	2	2	0.04	0.06	0
Dendrocopos canicapillus	*FO*	*IN*	12	17	0.17	0.22	0.17
Dendrocopos macei	*FO*	*IN*	11	11	0.04	0.22	0.25
Picus chlorolophus	*FO*	*IN*	8	10	0.08	0.17	0.13
Picus flavinucha	*FO*	*IN*	3	5	0.08	0.06	0
Picus xanthopygaeus	*FO*	*IN*	3	3	0.04	0	0.08
Picus canus	*FO*	*IN*	2	3	0	0	0.08
Dinopum shorii	*FO*	*IN*	21	34	0.13	0.39	0.46
Dinopium benghalense	*FO*	*IN*	4	4	0.08	0	0.08
Chrysocolaptes lucidus	*FO*	*IN*	1	1	0.04	0	0
Mulleripicus pulverulentus	*FO*	*IN*	1	2	0	0.06	0
Hemipus picatus	*FO*	*IN*	1	8	0	0.06	0
Tephrodornis pondicerianus	*FO*	*IN*	1	16	0	0.06	0

Continue

Appendix continued

Species	Type	Food	No. sites	No. individuals	NPforest	BZForest	BZCForest
Artamus fuscus	*FO*	*IN*	2	2	0.04	0	0.04
Aegithina tiphia	*FO*	*IN*	24	71	0.54	0.44	0.13
Coracina macei	*FO*	*IN*	29	44	0.38	0.44	0.5
Coracina melaschistos	*FO*	*IN*	2	2	0	0	0.08
Pericrocotus cinnamomeus	*FO*	*IN*	5	10	0.08	0	0.13
Pericrocotus flammeus	*FO*	*IN*	7	75	0.21	0.06	0.04
Lanius schach	*OP*	*IN*	13	16	0.17	0.22	0.21
Oriolus xanthornus	*FO*	*OM*	52	95	0.63	0.94	0.83
Oriolus oriolus	*FO*	*OM*	2	2	0	0.06	0.04
Dicrurus macrocercus	*ST*	*IN*	22	35	0.25	0.33	0.42
Dicrurus caerulescens	*FO*	*IN*	16	20	0.25	0.22	0.25
Dicrurus annectans	*FO*	*IN*	1	2	0	0.06	0
Dicrurus hottentottus	*FO*	*IN*	20	34	0.17	0.33	0.42
Dicrurus paradiseus	*FO*	*IN*	6	6	0.17	0.06	0.04
Rhipidura albicollis	*FO*	*IN*	4	5	0.17	0	0
Rhipidura aureola	*FO*	*IN*	2	2	0.04	0.06	0
Dendrocitta vagabunda	*FO*	*FR*	36	55	0.21	0.67	0.79
Corvus splendens	*ST*	*OM*	8	22	0.13	0.06	0.17
Corvus macrorhynchos	*ST*	*OM*	28	47	0.25	0.61	0.46
Culicicapa ceylonensis	*FO*	*IN*	14	73	0.5	0	0.08
Parus major	*FO*	*IN*	34	109	0.5	0.56	0.5
Pycnonotus melanicterus	*FO*	*OM*	3	6	0.13	0	0
Pycnonotus jocosus	*FO*	*OM*	30	132	0.67	0.61	0.13
Pycnonotus cafer	*FO*	*OM*	27	155	0.63	0.44	0.17
Riparia paludicola	*WT*	*IN*	16	330	0.29	0.22	0.21
Phylloscopus fuscatus	*FO*	*IN*	2	3	0.04	0	0.04
Phylloscopus affinis	*FO*	*IN*	2	4	0	0	0.08
Phylloscopus humei	*FO*	*IN*	1	1	0.04	0	0
Phylloscopus trochiloides	*FO*	*IN*	33	57	0.54	0.5	0.46
Phylloscopus magnirostris	*FO*	*IN*	4	11	0.04	0.06	0.08
Phylloscopus reguloides	*FO*	*IN*	3	3	0.13	0	0
Acrocephalus dumetorum	*FE*	*IN*	3	4	0.13	0	0
Prinia cinereocapilla	*FE*	*IN*	2	14	0.08	0	0
Prinia hodgsonii	*FE*	*IN*	16	50	0.29	0.22	0.21
Prinia inornata	*FE*	*IN*	5	15	0.04	0.06	0.13

Continue

Appendix continued

Species	Type	Food	No. sites	No. individuals	NPforest	BZForest	BZCForest
Orthotomus sutorius	*FE*	*IN*	35	59	0.46	0.56	0.58
Pellorneum ruficeps	*FO*	*IN*	18	52	0.54	0.17	0.08
Macronous gularis	*FO*	*IN*	7	18	0.21	0.11	0
Timalia pileata	*OP*	*IN*	7	31	0.17	0.11	0.04
Turdoides striata	*OP*	*IN*	23	162	0.25	0.33	0.46
Zosterops palpebrosus	*FO*	*IN*	18	70	0.38	0.28	0.17
Sitta castanea	*FO*	*IN*	19	41	0.13	0.33	0.42
Sitta frontalis	*FO*	*IN*	12	22	0.13	0.11	0.29
Acridotheres fuscus	*FO*	*OM*	21	108	0.13	0.61	0.29
Acridotheres tristis	*ST*	*OM*	8	31	0.04	0.11	0.21
Gracupoca contra	*ST*	*OM*	5	21	0	0.11	0.13
Sturnia malabarica	*FO*	*OM*	4	38	0	0.11	0.08
Copsychus malabaricus	*FO*	*IN*	18	20	0.29	0.28	0.25
Copsychus saularis	*FO*	*IN*	2	2	0.04	0.06	0
Saxicola torquatus	*OP*	*IN*	2	2	0.04	0	0.04
Saxicola caprata	*OP*	*IN*	5	9	0.08	0.11	0.04
Saxicola ferreus	*FE*	*IN*	3	3	0.13	0	0
Muscicapa sibirica	*FO*	*IN*	1	1	0.04	0	0
Ficedula parva	*FO*	*IN*	27	35	0.46	0.22	0.5
Eumyias thalassinus	*FO*	*IN*	7	11	0.04	0.33	0
Cyornis poliogenys	*FO*	*IN*	22	31	0.29	0.44	0.29
Cinnyris asiaticus	*FO*	*FR*	1	1	0.04	0	0
Aethopyga siparaja	*FO*	*FR*	2	3	0.08	0	0
Ploceus philippinus	*OP*	*IN*	4	160	0.04	0	0.13
Lonchura punctulata	*ST*	*IN*	3	18	0	0.06	0.08
Motacilla alba	*WT*	*IN*	2	3	0	0	0.08
Motacilla maderaspatensis	*WT*	*IN*	4	7	0.08	0.06	0.04
Anthus hodgsoni	*FO*	*IN*	8	35	0.04	0.06	0.25
Emberiza lathami	*OP*	*FR*	2	7	0.08	0	0

NPForest=National Park forest sites, BZForest= Buffer forests, BZCForest=Community forests

Note: Forest species (FO) represents habitat associate mainly in forest, wetland species (WT) include habitat associated with river, ponds and lakes, open area species (OP) symbolize habitat associated to open area and grassland, settlement species (ST) include habitat associated to human habitation and cultivation and Edge species (FE) include species prefer to live in the forest edge in habitat category. Food category Insectivores (IN) include species which use insects as main food ,similarly, Raptors(RA) which are eating mammals and birds, Piscivores (PI) are fish and amphibians eating, Frugivores (FR) seed, fruits and nectars and Omnivores (OM) represents the species which use almost all type of food.