

**Mammalian Fauna in Coffee Plantations of the Western
Ghats: Ecological and Legal Factors Affecting
Conservation**

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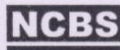
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Certificate

I declare that this thesis entitled "Ecological and legal factors affecting the conservation of mammalian fauna in coffee plantations of the Western Ghats" comprises research work carried out by Archana Bali at the Centre for Wildlife Studies under my guidance and the co-guidance of Dr. Jagdish Krishnaswamy and Dr. Kartik Shanker during the period 2005-2006 for the Degree of Master of Science in Wildlife Biology & Conservation of the Manipal Academy of Higher Education (MAHE). The results presented in this thesis have not been submitted previously to this or any other University for M.Sc. or any other degree.

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Summary

The Western Ghats forests have undergone extensive fragmentation due to conversion to plantations. Coffee plantations, covering around 3600 sq km, often occur within or surround protected areas and other forests and therefore are critical for biodiversity conservation in the region. I examined the richness and abundance of mammals (excluding bats, murids and shrews) in coffee plantations around Bhadra Wildlife Sanctuary with respect to distances from the forest and vegetation characteristics. I also examined the constraints imposed on conservation in coffee estates due to legislations and their implementation, local practices and awareness.

This study was carried out from December 2005 to May 2006, when I sampled 15 coffee estates. At least 28 species of mammals were recorded. Proximity to the Sanctuary was the most important factor that influenced species richness in coffee plantations. Species richness, surprisingly, declined with tree species richness and the abundance of fruit trees. Response of mammals to these factors could be species-specific, depending on their ecology, life history and behaviour. Such relationships therefore should be examined at species level and not at community level.

The Karnataka Preservation of Trees Act, 1976 (KPTA) and Indian Wildlife (Protection) Act, 1972 (WLPA) were analysed with regard to their content and lacunae. I found a lack of information and awareness among the planters regarding these legislations, and a lack of implementation from the Forest Department. WLPA does not address the issue of extending protection outside it, even for critical landscapes like the coffee plantations. I conclude that there is a need for a bottom up approach that focuses on changing attitudes through education. The Forest Department should recognize the conservation potential of coffee plantations and strengthen the implementation framework.

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Introduction

Forest reserves are increasingly becoming islands embedded in a matrix of human altered habitats of various kinds. Species survival in such fragmented landscapes often depends on the matrix that surrounds remnant forests. The attributes of the matrix play an important role in species diversity and composition in the patches of forests (Hanski and Gilpin 1991).

In addition to influencing the survival of species in remnant forests, matrixes are habitats for a wide range of permanent residents, some of which may occur only in the matrix (Kumar 2003). Matrix lands provide valuable environmental and biodiversity conservation benefits such as wildlife habitats and linkages between protected areas (Janzen 1998, Siebert 2001). Potential of coffee plantations to support rich biodiversity (Estrada et al. 1993, Perfecto et al. 1996, Moguel and Toledo 1999, Petit and Petit 2003) as well as its role as an important matrix among forest patches (Siebert 2001) has been widely documented.

Coffee plantations in India occupy a place of critical importance in the biodiversity-rich Western Ghats (Damodaran 2002, Das et al. 2006). These plantations are located in and around most of the protected areas, covering approximately 3600 km². The presence of friendly matrix around the forests of Western Ghats is very important as it harbors globally important populations of tiger and elephant and other endemic fauna. The biodiversity in coffee plantations is related to the vegetation structure and in severely fragmented landscapes, coffee plantations under natural shade are likely to be very critical for persistence of the forest biota (Gallina et al. 1996, Perfecto et al. 1996 Greenberg et al. 1997).

However, modernization of coffee cultivation has led to development of more robust higher yielding varieties of coffee, which require less shade. This has resulted in conversion of these

natural and mixed shade plantations into plantations with fewer and exotic monoculture shade trees such as silver oak. Such conversions have been associated with loss of biodiversity across different types of coffee plantations ranging from traditional to modern practices (Perfecto and Snelling 1995, Greenberg et al. 1997, Rappole et al, 2003).

There is a growing campaign driven by conservation as well as scientific organizations to promote shade-grown coffee as a means for preserving biodiversity in the tropics (Rappole et al. 2003, Sherry 2000). While the importance of coffee plantations as an opportunity for conservation has been widely recognized elsewhere, this is not true of the Western Ghats. So far, there is no pro-active role played by coffee enterprises in India towards biodiversity conservation in coffee plantations.

The goal of this study was to examine the scope for conservation of mammals in coffee plantations and the possible constraints in terms of existing legislations, level of awareness and the local practice in the coffee plantations. The study was carried out in coffee plantations surrounding Bhadra Wildlife Sanctuary in Chikmagalur, Karnataka, from December 2005 to May 2006.

In Chapter 1, I examine the factors that influence mammalian communities in coffee plantations. I compare the mammal communities in different guilds with distance from forest and vegetation characteristics, to identify the major drivers of species richness and abundance. This chapter has been formatted as a draft manuscript for the Conservation Biology journal.

Chapter 2 focuses on legislations that directly or indirectly influence wildlife conservation in coffee plantations. The two pieces of legislation examined are (a) The Indian Wildlife

(Protection) Act, 1972 and (b) Karnataka Tree Preservation Act, 1976. Both acts are analysed with regard to their content and lacunae. The relationship between implementation of these legislations by the authorities and perceptions of the coffee planters and other stakeholders are examined.

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CHAPTER 1

Coffee plantations in Western Ghats: Conservation implications with reference to mammalian fauna

Abstract

The Western Ghats forests have undergone extensive fragmentation due to conversion to plantations. Coffee plantations, covering around 3600 sq km, occur often within or adjacent to forest patches. This matrix is used by a wide range of fauna, both resident and transient. I examined the richness and abundance of mammals (excluding bats, murids and shrews) in coffee plantations around Bhadra Wildlife Sanctuary with respect to local and landscape covariates. Fifteen estates, at varying distances from the Sanctuary were sampled between December 2005 and May 2006. Mammal species richness and composition were estimated from indirect evidences in belt transects and track plots. At least 28 species of mammals were recorded, representative of dry and moist deciduous forest in the region. Distance from contiguous forest was the most important factor that negatively influenced species richness, overall and guild wise, except for frugivores. The specialists showed a strong decline in species richness with increase in distance from the forest. Overall and guild wise species richness showed negative relationship with tree species richness and number of fruit trees. The carnivores were positively related with percentage of silver oak, a preferred shade and timber species. In the estates with high silver oak abundance, the planters retained the *Ficus* species for permanent shade. I infer that at present the extent of silver oak is not impacting mammals negatively. The large mammals have large home ranges, and may use coffee plantations only as feeding or resting site or for movement across the forest fragments. Small to mid-sized mammals could be resident in coffee plantations due to availability of resources

through out the year and reduced predation pressure. Response of mammals to these factors could be species-specific, depending on their ecology, life history and behaviour. Such relationships therefore should be examined at species level and not at community level.

Introduction

The Western Ghats, a biodiversity hotspot of global significance (Myers et al. 2000), has undergone extensive fragmentation due to the conversion of natural forests to plantations of tea, coffee, cardamom, and teak (Menon & Bawa 1997). Several protected areas that have been established in the remaining forests are embedded in a matrix of these plantations. Coffee plantations in particular cover nearly 3,500 km² (Coffee Board of India 2005) of Western Ghats and often surround or are surrounded by protected areas. This juxtaposition of land-use types provides a unique opportunity to examine the factors that influence the use of such a matrix by wildlife.

When coffee cultivation was introduced in India in the 1740s, it replaced the best patches of mid-elevation moist deciduous and rainforests. Mid-elevation forests are known to be the most species rich, due to their ecotonal characteristics and the mid-domain effect (Rahbek 1995). Since then, extensive conversion of forests into plantations and other agricultural habitats has led to further fragmentation and isolation of vertebrate populations.

Several studies (Siebert 2002; Kumar 2003; Das et al. 2006) have shown that the resultant matrices of land use types are important for three reasons:

- They are used as corridors by several species for movement between patches of remnant forests.
- They have resident populations of several species, some of which occur exclusively within the matrix.
- They are used by several species as feeding or breeding grounds.

Factors that influence animal occurrence in and around remnant forest patches have therefore been of considerable theoretical and conservation interest for the past several decades (Estrada et al. 1994; Moguel & Toledo 1999; Daily et al. 2003). The agricultural and forest land outside formally protected areas could potentially play an important role in managing biodiversity (Janzen 1998), hence an understanding of these factors is of considerable conservation importance (Siebert 2002). Studies elsewhere have shown that coffee plantations have high structural complexity and vegetation diversity and can have relatively high biodiversity (Perfecto et al. 1996). The importance of coffee plantations for biodiversity conservation is not only in the large area it occupies but also in the strategic location in and around severely fragmented forests (Perfecto et al. 2005). Therefore, coffee plantations provide good opportunities for conservation of wildlife outside protected areas while acting as a buffer to the protected areas. There is a growing campaign driven by conservation agencies as well as scientific organizations to promote shade-grown coffee as a means for preserving biodiversity in the tropics (Sherry 2000; Rappole et al. 2003).

In this context, the goal of this study was to enhance our understanding of biodiversity values of coffee plantations. This was addressed by studying non-volant mammalian communities (excluding murids) in coffee plantations. The mammalian community was chosen because mammals show a wide range of responses to habitat alterations due to their diverse ecologies and life histories as well as their differential scale of sensitivity as opposed to many other taxa. Similarly, coffee plantations provide a variety of habitat alterations that are quantifiable. There has been limited research across the world focusing on mammals in coffee plantations (Daily et al. 2003), and none so far in India. The ecosystem chosen for this study was a mid-elevation moist deciduous forest that has seen significant conversion into coffee plantations.

The specific objectives of this study were:

1. To characterize the mammal communities in coffee dominated landscapes; and
2. To compare mammal communities in three feeding guilds: carnivores, herbivores and frugivores, under different coffee systems and identify the major drivers of these differences.

Among the major drivers are: distance to the nearest forest, the nature and characteristics of native vegetation, and the extent of the exotic shade trees, silver oak *Grevillea robusta*.

Methods

Study Area

Fieldwork was carried out from December 2005 to May 2006 in the coffee landscape around moist deciduous forests of Bhadra Wildlife Sanctuary and adjacent reserve forests in the Chikmagalur district of Karnataka, India (Figure 1). Elevation of Chikmagalur ranges from 700-1200 above m MSL. The mean temperature varies from 15° to 30° Celsius. Rainfall is highly variable from location to location due to topography of the region, ranging from 1000 to 4500 mm (Coffee Board of India 2005). Mean annual precipitation for the entire region is approximately 1800 mm. The region receives pre-monsoon showers in the months of March and April, and southwest monsoon from June to September. December to March are normally dry months.

Coffee plantations are located around the Bhadra Wildlife Sanctuary. The Sanctuary is spread across Chikmagalur and Shimoga Districts in 492.46 km². The Sanctuary takes its name from its lifeline, the River Bhadra. The predominant vegetation type in the region varies from moist deciduous to semi-evergreen, with patches of *shola*-grassland habitat at the higher altitudes.

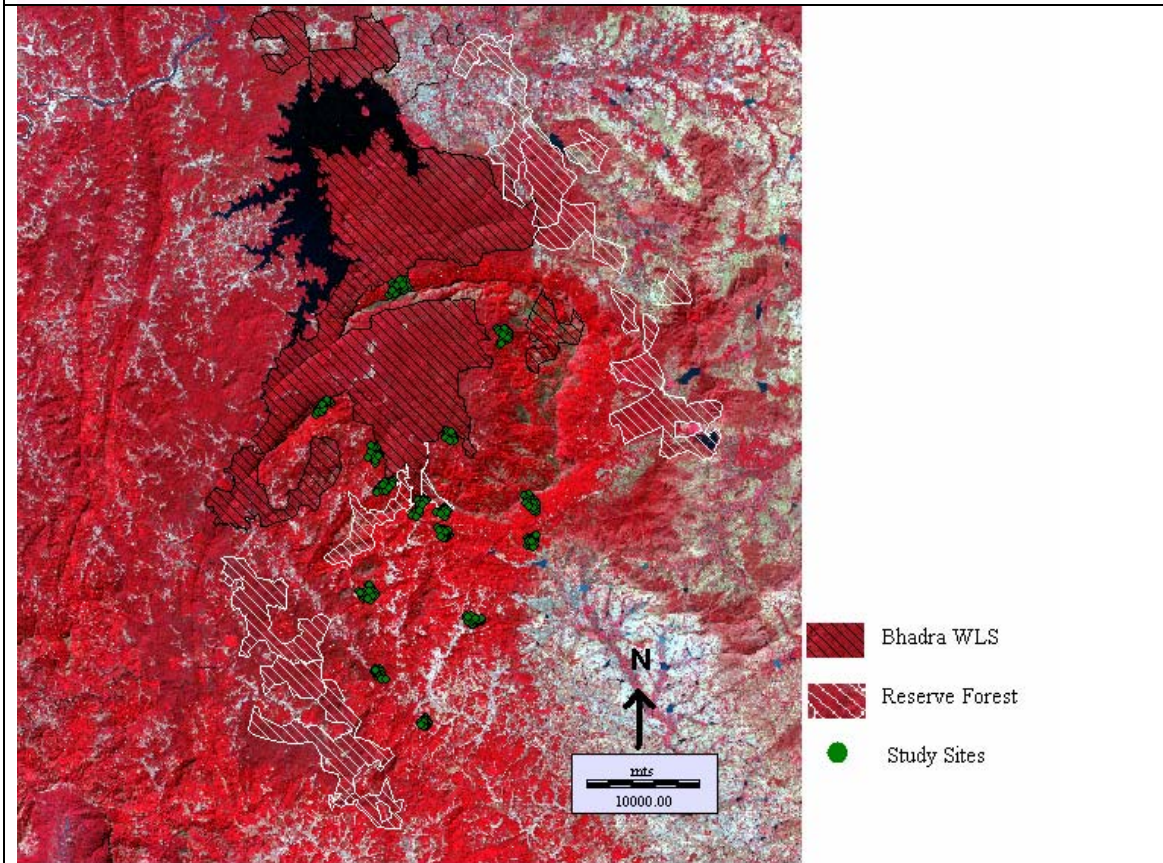
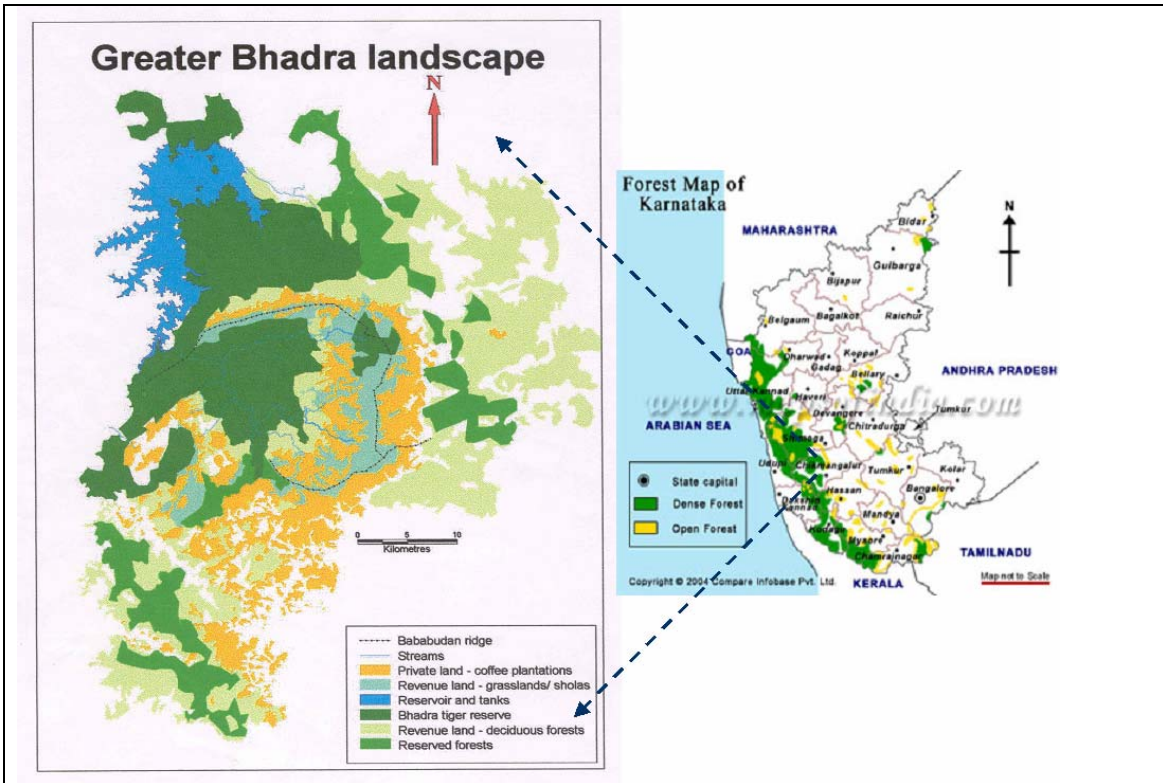


Figure 1. The Greater Bhadra landscape (Top), Locations of study sites (bottom)

Some of the common trees seen in the coffee plantations are *Ficus glomerata*, *F. retusa*, *F.tsiela*, *Terminalia alata*, *Bischoffia javanica* and *Artocarpus integrifolia*. However silver oak (*Grevillea robusta*) is the most abundant species in the coffee landscapes. Main intercrops along with coffee are pepper (*Piper nigrum*), arecanut (*Areca catechu*) and orange (*Citrus sp.*).

Chikmagalur is the largest coffee producing area in India. Both *Coffea arabica* and *C. robusta* are grown here over about 87,000 ha, constituting approximately 24% of total land under coffee production in the country. This region contributes 25% of total coffee production and 40% of total production of *C. arabica* variety (Coffee Board of India 2005). Since *C. arabica* requires more shade in comparison to other coffee varieties, it accounts for a high proportion of coffee production under natural shade (Damodaran 2002).

Field Methods and Data Analysis

Sampling mammals:

Fifteen coffee estates were selected as sampling units based on the a) distance from the Bhadra Wildlife Sanctuary (hereafter referred to as Bhadra) and b) the extent of silver oak. At each site, mammal species richness and composition were estimated using the following methods:

- a) Belt transects were sampled for indirect evidences of mammals (other than bats and murid rodents), such as droppings (scat, dung and pellets) and tracks along existing trails and footpaths (as well as between coffee bushes). Each belt-transect was 250×2 m. Twelve such transects were sampled at each estate. Belt transects were at least 200 m away from each other. The number of individual droppings, tracks and other evidences were recorded for each species detected. Estate number 15 (Table 1) was

excluded from belt transects because the estate had removed leaf litter just prior to sampling.

- b) Track plots were set up to sample small terrestrial species. Twelve track plots were set up at each site and monitored for three consecutive nights. Exceptions to this were estate number 12, 13 and 15. In these three estates, rains disturbed track plots for 1 night in each site. To compensate, track plots were monitored for one additional night in estate 12 and 13, while due to lack of time in estate number 15 track plots were monitored for only 2 nights. Track plot visitation was defined as the occurrence of mammalian tracks (of one or more species) in any track plot, irrespective of whether they were identified or not. The track plots were of 1 m diameter and at least 200 meters apart from each other. The track plots were baited with chicken entrails and rotten fruits. They were set up every evening between 1600 hours and 1800 hours, and checked the following morning between 0600 hours and 0900 hours. Tracks of species that visited the plots were identified and recorded. Since tracks of small carnivores are difficult to identify to the species level, tracks were assigned to the following groups: small cats (jungle, leopard, rusty spotted cat and feral cat), mongooses (grey, ruddy, stripe-necked and brown mongoose), and palm civets (common and brown palm civets).
- c) Night transects were conducted between 1900 hours and 2100 hours, using a torchlight for detecting nocturnal mammals. The length of the night transect in each estate was approximately one km and it was walked twice, except for estate number 15, where it was walked only on one night.

- d) All opportunistic sightings of mammals were recorded. However, these sightings did not contribute any additional species to overall species richness.

Sampling vegetation:

Trees (>10 cm gbh) were enumerated from three plots (5m x 5m) along each belt transect, resulting in a total of 36 plots for each estate. Species, which are food resources for mammals were identified from scats, literature and local knowledge.

The following vegetation characteristics were estimated for each estate:

- Percentage of silver oak
- Mean number of trees per plot
- Mean number of species per plot
- Mean basal area per plot
- Abundance of fruit trees per plot

Estimating distance from forest:

GPS locations of each track plot and belt transect were recorded. Distance of each GPS location from Bhadra and reserve forests was extracted from the digitized forest layer of Greater Bhadra landscape (French Institute 1985) using the GIS software IDRISI ver 14.2 (Clark Labs, 2003). The shortest distance of each estate from the Bhadra forest was used for distance analysis. Since distance ranged from 0 m to 18,705 m, it was \log_n transformed.

Pooled species richness was estimated for each site, which included mammal species recorded using all three methods as well as opportunistic sightings. Data across different sites were compared in terms of proportion of track plots visited and total number of encounters pooled



Picture 1. Coffee plantations under: Natural shade (Top) and Silver oak shade (Bottom).



Picture 2. Indirect evidences of mammals: Scats (Top) and track marks (Bottom).

across all transects for each species. Here each ‘*encounter*’ is defined as either a sighting or indirect sign.

This approach is used to understand patterns of overall mammal species richness and abundance, and that of three feeding guilds: frugivores, herbivores and carnivores. Frugivores included bonnet macaque (*Macaca radiata*), palm civets (*Paradoxurus* sp.), small Indian civet (*Viverricula indica*), Indian giant squirrel (*Ratufa indica*), dusky striped squirrel (*Funambulus sublineatus*), jungle-striped squirrel (*F. tristriatus*), large brown flying squirrel (*Petaurista philippensis*) and common langur (*Semnopithecus entellus*). Herbivores included gaur (*Bos gaurus*), sambar (*Cervus unicolor*), spotted deer (*Axis axis*), muntjac (*Muntiacus muntjak*), chevrotain (*Moschiola meminna*), Asian elephant (*Elephas maximus*) and wild pig (*Sus scrofa*). Carnivores included small cats (*Felis* spp., *Prionailurus* spp.), mongoose (belonging to the genus *Herpestes*), leopard (*Panthera pardus*), tiger (*P. tigris*), wild dog (*Cuon alpinus*) and jackal (*Canis aureus*).

In addition to this, all mammals were categorized into two groups based on the dependency on forest habitats and/ or preference for undisturbed habitat, namely – generalist and specialist mammals. The generalists included: common palm civet (*Paradoxurus hermophroditus*), small Indian civet (*Viverricula indica*), black-naped hare (*Lepus nigricollis*), bonnet macaque (*Macaca radiata*), wild pig (*Sus scrofa*), jungle-striped squirrel (*Funambulus tristriatus*), Indian giant squirrel (*Ratufa indica*), jackal (*Canis aureus*) and porcupine (*Hystrix indica*). The specialists included: tiger (*Panthera tigris*), leopard (*P. pardus*), sloth bear (*Melursus ursinus*), wild dog (*Cuon alpinus*), Asian elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), spotted deer (*Axis axis*), muntjac (*Muntiacus muntjak*), chevrotain (*Moschiola meminna*), common langur (*Semnopithecus entellus*), dusky striped squirrel

(*Funambulus sublineatus*) and large brown flying squirrel (*Petaurista philippensis*). This categorization did not include small cats and mongooses because species in these groups could not be identified reliably from tracks and droppings.

Exploratory data analysis was done using SPSS ver11.5 (SPSS Inc., 2002). Variables were tested for normality. Parametric statistical tests such as bivariate correlation and linear regression were used to assess relationships between different variables. The strength of relationships has been expressed using Pearson's correlation coefficient r along with p value. Cut-off for type-1 error, α was fixed at 0.05. Measures of central tendencies have been presented along with the standard errors (mean \pm SE). The sample size is 15 unless otherwise specified.

Results

Estate description

The 15 coffee estates ranged in area from 44 ha to 160 ha (Table 1). The estates were located at least one km away from each other. The estates ranged in distance from 0 m to 19 km from Bhadra forest. Distance to nearest forest ranged from 0 m to 9,000 m. Three estates were situated adjacent to Bhadra forest, sharing at least one boundary with the forest. The altitude of these estates ranged from 761 m to 1503 m with a mean of 1095 m. Altitudinal variation within estates ranged from 74 m to 354 m. Within the altitudinal range covered in this study, neither mammal species richness nor vegetation characteristics showed any relationship with mean altitude or altitude range.

Estate No.	Estate Name	Area (ha)	Altitudinal Range (m)	Minimum distance from Bhadra forest (m)	Minimum distance from nearest reserve forest (m)
1	Shivagange	132	1181 - 1374	1881	0
2	Hosakan	160	973 - 1172	0	2113
3	Katlekan	152	825 - 1178	0	10901
4	Kondadkan	140	940 - 1223	206	7238
5	Chinanhalli	128	1178 - 1306	2931	823
6	Gowankan	84	1052 - 1304	185	0
7	Kesvinmane	80	803 - 1066	894	7655
8	Lakshmi	72	761 - 840	0	1669
9	Vasanthcool	88	1107 - 1238	8376	6891
10	Mylemoney	94	1119 - 1265	10740	8572
11	Kendalhaklu	90	816 - 928	14356	3332
12	Lower Kuttinkan	100	844 - 998	328	362
13	Arabidcool	130	1186 - 1503	5488	6236
14	Bettadamalali	160	1039 - 1311	7662	2225
15	Yellikodige	44	1083 - 1158	18253	3519

Table 1. General description of the 15 estates.

Vegetation characteristics

Tree species richness as estimated from 36 vegetation plots ranged from 17 to 38 species per estate (Table 2) with a mean of 27.57 (± 1.71) and a median of 26. A total of 93 species were recorded from 14 estates out of which eight species of garden trees such as *Delonix regia* (Gulmohur), *Plumeria rubra* (Pagoda tree) and *Jacaranda sp.* were excluded from the analysis. These trees were planted around the estate bungalows and in the gardens. The eight excluded species resulted in the removal of 16 trees from a total of 1638 trees overall. The net number of species amounted to 85 in 14 estates.

Total number of trees in 36 vegetation plots ranged from 84 to 169, with a mean of 118.86 trees (± 7.50) and median of 110. This resulted in 3.34 trees (± 0.21) and 2.59 species (± 0.13) per plot. Silver oak was the most abundant species followed by *Erythrina lithosperma*. Out of total trees recorded in 14 estates, 30% of all were silver oak. *Erythrina lithosperma* is a fast growing species and therefore along with orange *Citrus sp.*, is one of the favorite among

planters as a middle canopy shade tree. In estates with higher abundance of silver oak, *Erythrina indica* is grown to enhance shade. *Ficus glomerata*, *Artocarpus integrifolia* (jackfruit), *Sapindus laurifolius* (soapnut), *Syzigium cuminii* and *Tuna ciliata* were found in all estates at high abundances. Soapnut is harvested and supplied to the soap industry and hence it is heavily planted because of the economic returns. *Dalbergia lalifolia* (rosewood) was recorded in 11 estates but at very low abundances. All estates had pepper vines and nine estates had *Areca catechu* (areca nut) as a supplement crop.

Estate No.	No. of species	% Silver oak	Mean no. of trees per plot	Mean no. of species per plot	Mean basal area per plot	No. of fruit tree species	No. fruit trees	No. of ficus trees
1	31	31.95	4.69	3.47	1430.99	12	47	20
2	31	33.13	4.44	3.42	914.50	11	60	16
3	20	52.66	4.69	2.36	1192.32	8	20	14
4	27	14.44	2.5	2.33	1971.37	11	46	18
5	24	34.48	3.22	2.83	1557.89	11	48	18
6	36	11.40	3.17	2.89	2083.49	12	52	14
7	38	11.21	2.97	2.72	1125.71	18	48	17
8	22	38.78	2.72	2.11	1600.35	9	18	6
9	31	30.53	3.74	2.77	989.77	16	43	13
10	25	21.50	3.06	2.63	2998.33	12	52	23
11	24	25.93	3.09	2.51	1069.08	8	30	12
12	36	20.20	2.83	2.26	1496.42	14	27	10
13	24	34.52	2.33	1.83	2646.49	10	28	14
14	17	43.75	3.29	2.18	478.43	6	24	8

Table 2: Description of vegetation characteristics of 14 estates estimated from 36 vegetation plots.

Tree species that were identified as food resources for frugivores and herbivores are grouped as *fruit trees*. The number of fruit tree species recorded per estate ranged from six to 19 species (mean = 11.29 ±0.85). Abundance of fruit trees ranged from 18 to 60 trees per estate with a mean of 38.79 (±3.66) and a median of 44. Trees belonging to *Ficus spp.* were present in all estates at high abundance, with *F. glomerata* being the most abundant of all. Other wide spread species were *F. infectoria*, *F. amplissima*, *F. drupacea*, *F. microcarpa* and *F. lacor*. On average 39.03% (±2.95) of all fruit trees per estate belonged to *Ficus spp.* The number of *Ficus* trees in 36 plots ranged from six to 23, with a mean of 14.50 (±1.24) trees per estate.

The proportion of silver oak ranged from 11.21% to 52.66% with a mean of 28.89% (± 3.27) and a median of 31.24.

The proportion of silver oak was negatively correlated with tree species richness within estates, as estimated from 36 vegetation plots ($r = -0.76$, $p = 0.002$). It was also negatively correlated with abundance of fruit trees ($r = -0.60$, $p = 0.02$, Figure 2). Species richness was positively correlated with the abundance of fruit trees ($r = 0.59$, $p = 0.02$).

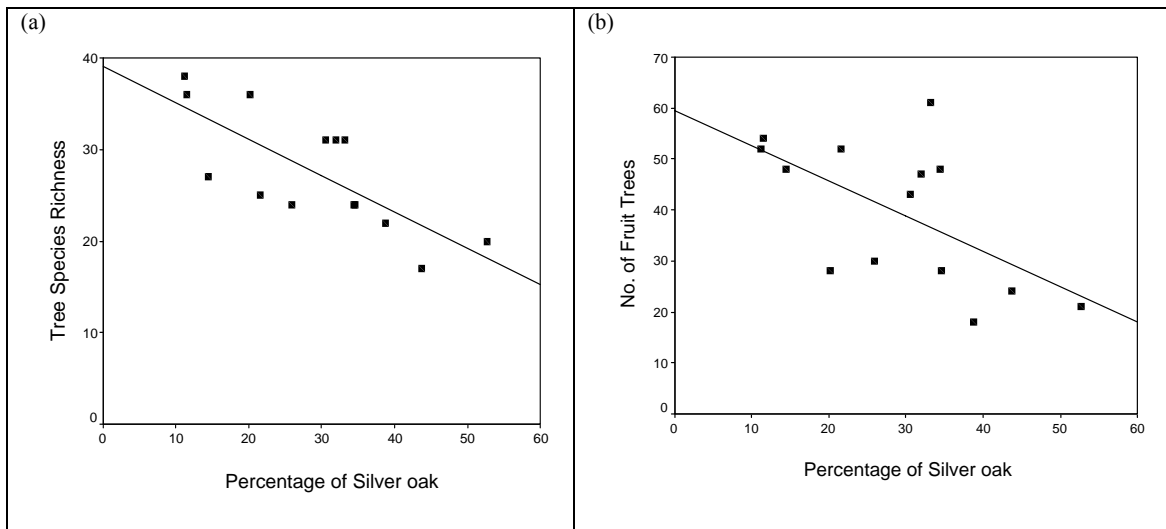


Figure 2. Effect of Silver oak on (a) Tree Species Richness ($R^2 = 0.57$) and (b) Abundance of Fruit Trees ($R^2 = 0.36$)

Mammal Species Richness

At least 28 species of non-volant, non-murid mammals were detected in 15 coffee estates (Table 3). Fifteen species were recorded from track plots in 15 estates and 24 species from belt transects in 14 estates. In 29 night transects, 25 mammals belonging to nine species were recorded. Number of species recorded in the 15 estates ranged from 5 to 19 with a mean of 11.80 (± 0.97) species per estate (median = 11). Other opportunistic sightings amounted to total of 45 mammals in 11 species.

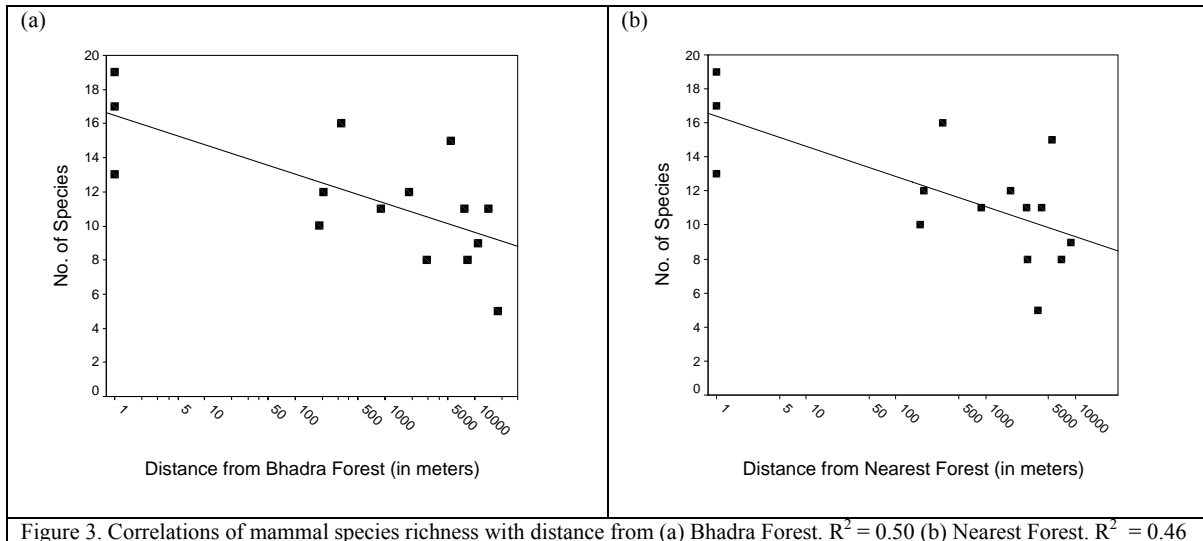
Species	No. of tracks in Track Plots	No. of signs in Belt Transects	No of signs in Night Transects	Opportuni-stic sightings
Bonnet macaque <i>Macaca radiata</i>	11	353		
Common langur <i>Semnopithecus entellus</i>		4		1
Sambar <i>Cervus unicolor</i>		22		2
Mouse deer <i>Moschiola meminna</i>	1	4		
Indian Muntjac <i>Muntiacus muntjak</i>	15	70	2	9
Spotted deer <i>Axis axis</i>	13	46	1	9
Gaur <i>Bos gaurus</i>	3	19		2
Wild pig <i>Sus scrofa</i>	2	92	3	4
Asian elephant <i>Elephas maximus</i>			1	
Sloth bear <i>Melursus ursinus</i>	1	7		
Jackal <i>Canis aureus</i>	9	6	1	
Wild dog <i>Cuon alpinus</i>		9		
Tiger <i>Panthera tigris</i>		6		
Common leopard <i>P. pardus</i>	1	14		
Small cats** <i>Felis chaus</i> and <i>Prionailurus spp.</i>	68	48		1
Small Indian civet <i>Viverricula indica</i>	76	126	1	
Palm civets* <i>Paradoxurus spp.</i>	53	163	4	
Mongoose*** <i>Herpestes spp.</i>	32	9		6
Blacknaped hare <i>Lepus nigricollis</i>	9	266	2	5
Indian porcupine <i>Hystrix indica</i>	4	57		
Indian giant squirrel <i>Ratufa indica</i>		15		4
Jungle striped squirrel <i>Funambulus tristriatus</i>		28		
Large brown flying squirrel <i>Petaurista philippensis</i>			10	
Dusky striped squirrel <i>F. sublineatus</i>		3		2
Total Records	298 ^a	1367	25	45

Table 3: Method-wise summary of species encounter. ^a Total no of tracks pooled over various track plot nights. *Palm civets grouped together. Possible species are common palm civet *Paradoxurus hermophroditus* and brown palm civet *P. jerdoni*. **Small cats grouped together. Possible species are jungle cat *Felis chaus*, leopard cat *Prionailurus bengalensis*, rusty spotted cat *P. rubiginosus* and feral cat. ***Mongooses grouped together. 4 species of mongoose recorded in direct sightings: grey mongoose *Herpestes edwardsii*, ruddy mongoose *H. smithii*, stripe-necked mongoose *H. vitticollis* and brown mongoose *H. fuscus*.

Total species richness was negatively correlated to nearest distance from Bhadra ($r = -0.71$, $p = 0.003$, Figure 3a) and from reserve forest patch ($r = -0.68$, $p = 0.005$, Figure 3b).

Tiger signs were found only in three estates, all located on the periphery of Bhadra as far as 1016 m from the forest boundary (Table 1). On the other hand, leopard signs were recorded as far as 8699 m from Bhadra (3903 m from reserve forest). Sixteen leopard signs were recorded from six estates including the three estates adjacent to forest. Out of these, nine records were only from estate number two, including one sighting. However, frequent incidences of leopard attacks on dogs and cattle were reported by people from 13 estates. Wild dog and sloth bear

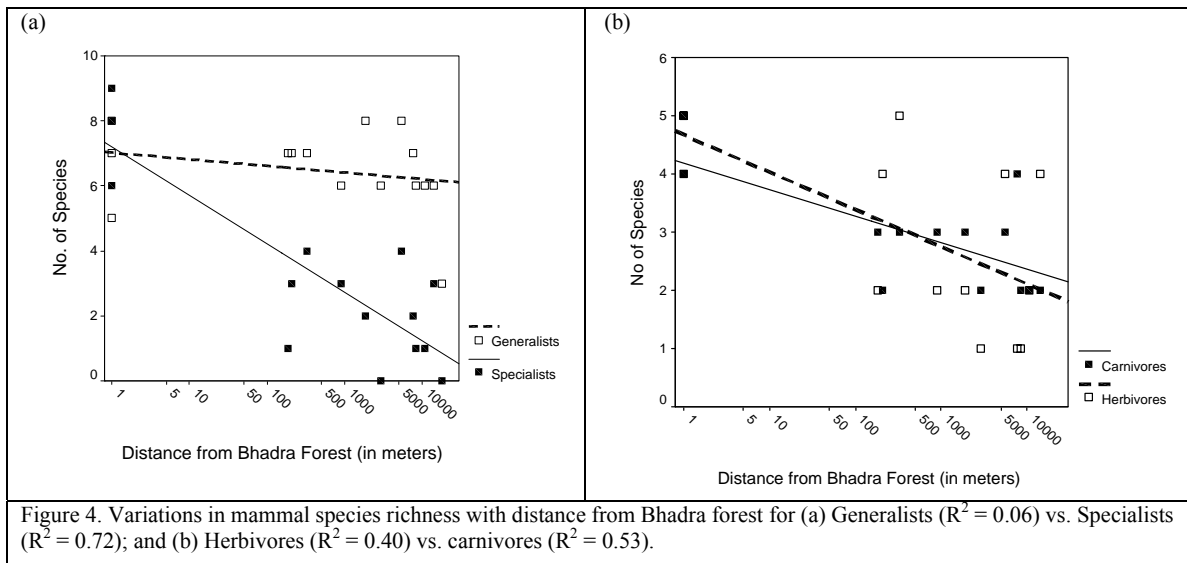
signs were recorded from only one estate (estate number three). All wild dog signs were less than 100 m from the forest boundary, while sloth bear signs were as far as 1,120 m.



Among large herbivores, elephant, gaur and sambar records were limited to estates close to forests. Gaur were recorded as far as 863 m while all sambar records were within 500 m. Chital were recorded from seven estates and found as far as 7,200 m from any forest. Muntjac was recorded from 13 estates and was the most abundant among herbivores after wild pigs. Langur were recorded from only one estate that was adjacent to forest (estate number 8), all sightings being less than 200 m from forest boundary. The species of langur found in this region is a sub-species of the common langur *Semnopithecus entellus* which is more forest dependent (A. Kumar, pers. comm.). Civets, mongoose, hare and bonnet macaque were recorded in most estates.

Group-wise, carnivores and herbivores showed a strong negative relationship with distance from Bhadra ($r = -0.75$, $p = 0.001$ and $r = -0.63$, $p = 0.01$ respectively, Figure 4b) while the number of frugivores were not affected by distance ($r = 0.38$, $p = 0.16$, Figure 4a). This is because carnivores included cats and mongooses, which are recorded almost everywhere.

When, mammals were grouped into 2 categories based on their dependence on forest and tolerance of human disturbance, specialist mammals – which included species that are mainly confined to forest habitats, showed a sharp decline as distance from forest increased ($r = -0.85$, $p = 0.00$), while the generalist mammals did not show any significant relationship with distance ($r = -0.04$, $p = 0.14$, Figure 4a).



To further investigate the influence of distance from forest, distance was classified into 4 categories (Table 4) and number of mammal species, overall as well as in the 2 groups was compared across these 4 categories.

Category	On log scale	Distance (in m)	No. of Estates
1	0-4.61	0-100	N=3
2	4.62-6.91	101-1000	N=4
3	6.92-8.99	1001-8000	N=4
4	9-9.90	8001-20000	N=4

Table 4. Four distance categories.

Estates close to forests had many more species than the estates away from forests. While overall species richness showed a gradual decline in each category (Figure 5), the two groups of mammals behaved very differently. Closer to forest, there were more specialists than generalists. After a distance of approximately 1 km, the specialists showed a sharp decline as distance increased and were replaced by generalists. Upto approximately 8 km, generalists were not affected, but beyond this there was decline in number of generalist species as well.

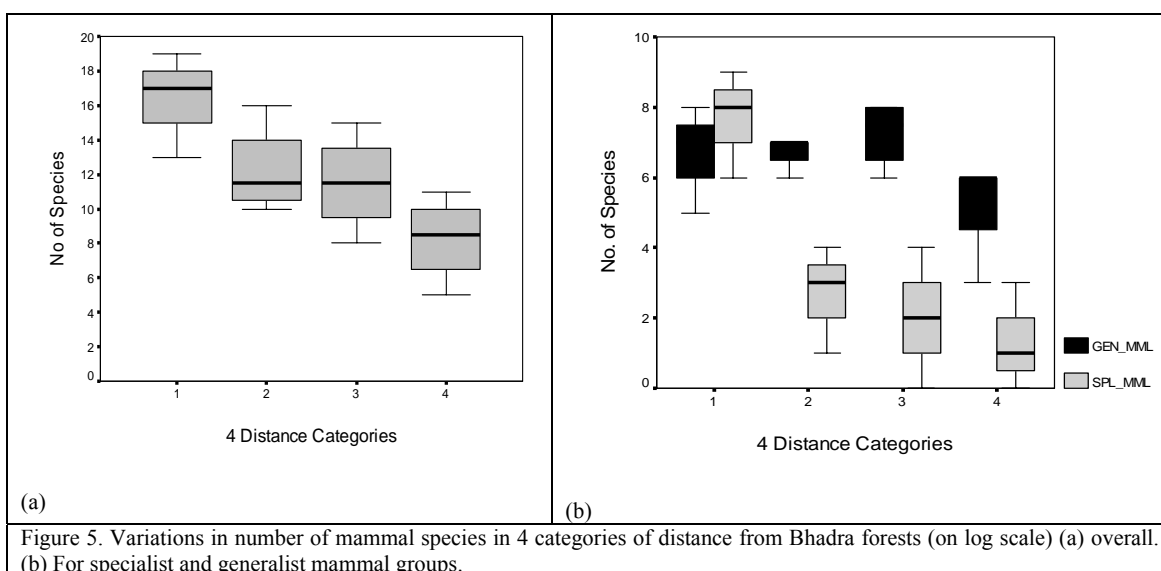


Figure 5. Variations in number of mammal species in 4 categories of distance from Bhadra forests (on log scale) (a) overall. (b) For specialist and generalist mammal groups.

Overall mammal species richness in an estate was not related to tree species richness. It was negatively correlated with abundance of fruit trees ($r = -0.65$, $p = 0.01$). Category-wise, generalist mammals showed a significant negative relation ($r = -0.57$, $p = 0.03$) while specialist mammals also showed a weak negative correlation with abundance of fruit trees ($r = -0.53$, $p = 0.053$). Carnivore richness showed a positive correlation with proportion of silver oak ($r = 0.62$, $p = 0.02$). Frugivores were negatively correlated with mean number of species per plot ($r = -0.57$, $p = 0.03$) as well as with mean number of fruit trees per plot ($r = -0.68$, $p = 0.008$). The herbivore guild showed no significant correlations with any of the vegetation characteristics.

Species Diversity: Regression

Distance proved to be the most important covariate for explaining variation in overall mammal species richness. Overall species richness of mammals, as well as group and guild wise, showed negative correlations with several vegetation characteristics. On the basis of the correlation matrix, the following vegetation characteristics, in addition to distance from Bhadra forest, were selected as predictors in linear regression: (1) Percentage of silver oak, (2) Mean number of fruit trees per plot, and (3) Mean number of species per plot

This showed that apart from distance, number of fruit trees per plot was negatively correlated with overall species richness, and that of specialists, generalists and frugivores. While the carnivores were positively related with percentage of silver oak, herbivores showed a relationship with only the distance from forest (Table 5).

Dependent Variable	Independent Variables	Slope	Cumulative R	Sig.
Overall mammal species richness	Distance	-0.585	0.687	0.007
	No. of Fruit trees per plot	-4.981	0.898	0.001
Generalist mammals	No. of Fruit trees per plot	-1.327	0.570	0.033
Specialists mammals	Distance	-0.589	0.833	0.000
	No. of Fruit trees per plot	-2.961	0.938	0.002
Herbivores	Distance	-0.283	0.613	0.020
Carnivores	Distance	-0.161	0.726	0.006
	Percentage of silver oak	0.034	0.837	0.029
Frugivores	No. of Fruit trees per plot	-2.818	0.676	0.008

Table 5: Regression table.

Abundance

Out of total a 552 track plot nights across 15 estates, 359 track plot nights (65% ± 20%) had visitations (Table 6). In 359 track plot nights, 453 tracks were recorded out of which 388 tracks of 15 species were identified. A total of 288 individual tracks from 154 track plots were recorded when visitations were pooled over all nights of sampling. Overall, out of 180 track

plots, 154 were visited at least once, 95 at least twice and 34 on three nights (estate number 15 was sampled for only two nights). On average each estate had 10.27 (± 0.40) or 85.56 % of track plots (of a total of 12 track plots) visited at least once; 6.33 (± 0.61) or 52.78 % plots visited at least twice and 2.27 (± 0.54) or 18.89 % plots visited on all three occasions.

The proportion of track plots visited in an estate was negatively correlated with tree species richness ($r = -0.68$, $p = 0.007$) and abundance of fruit trees ($r = -0.75$, $p = 0.002$) as estimated from 36 plots. It showed no correlation with distance from forest.

Out of a total of 168 belt transects in 14 estates, 1,367 detections of 24 species were recorded (Table 6). Of 168, only three belt transects had zero records, one each in estate number 7, 12 and 14. The number of encounters per estate in belt transects was found to be related only to basal area of trees. It was positively correlated with total basal area per estate (0.535, $p = 0.05$), mean basal area of fruiting trees (0.55, $p = 0.05$) and mean basal area of *Ficus* trees (0.58, $p = 0.05$). Large basal areas of trees are an indicator of big trees with large crowns. Hence, it can be inferred that animal abundance was related to density of trees and contiguity of canopy.

As common palm civet, small Indian civet and bonnet macaque were present in all estates in large numbers, data for these species were analyzed separately. Abundance of this group (pooled abundance of the three species) was positively related to tree density. It was found to be also correlated with total basal area of fruit trees ($r = 0.58$, $p = 0.03$) and mean basal area per plot ($r = 0.549$, $p = 0.04$). In addition, abundance of this group was negatively correlated with presence of carnivores ($r = -0.55$, $p = 0.04$). Civet abundance showed a positive correlation

with distance from Bhadra ($r = 0.55$, $p = 0.04$) as well as distance from nearest forest ($r = 0.61$, $p = 0.02$).

Estate No.	% of track plot nights visited	No. of tracks in track plots	Identified tracks	% of track plots visited*	No. of species in track plots	Mean no. of encounters per belt transects	No. of species in belt transects	Total species richness
1	47.22	18	12	66.67	4	6.17 (± 0.66)	11	12
2	75	38	35	91.67	6	8.17 (± 0.73)	13	13
3	47.22	22	20	91.67	6	11.75 (± 1.71)	16	17
4	58.33	23	20	91.67	5	4.25 (± 0.43)	11	12
5	75	32	31	100	4	12.33 (± 1.62)	8	8
6	77.78	38	38	91.67	7	10.75 (± 1.51)	10	10
7	27.78	11	11	58.33	3	3.67 (± 0.86)	11	11
8	63.89	32	27	83.33	9	15.08 (± 2.13)	19	19
9	58.33	26	20	75	5	6.58 (± 0.99)	8	8
10	88.89	40	35	91.67	6	9.83 (± 1.21)	8	9
11	86.11	46	39	91.67	9	8.00 (± 1.45)	11	11
12	47.92	25	16	75	8	4.33 (± 1.20)	12	16
13	72.92	47	37	100	7	9.17 (± 1.11)	12	15
14	75	29	26	100	6	3.83 (± 1.10)	11	11
15	83.33	26	21	75	5	--	--	5

Table 6: Estate-wise summary of track plots and belt transects. Number of track plot nights mentioned for each estate. Number of belt transects was same for each estate ($n=12$). Data presented for 552 track plot nights and summary of 180 track plots*. Total 15 species recorded in track plots and 24 in belt transects. Estate number 15 omitted from belt transects.

Discussion

The study shows that a rich pool of mammal species exists in coffee estates. At least 28 species of non-volant, non-murid mammals were recorded including the endemic species jungle-striped squirrel and probably brown palm civet, and the endemic subspecies of brown mongoose. This includes most species of mammals expected to occur in the moist deciduous and dry deciduous regions of the study area.

Distance from contiguous forest was an important factor that negatively influenced overall species richness, as well as guild wise species richness, except for the frugivores. The specialists showed very strong decline in number of species with increase in distance from the forest while the generalists were not affected so strongly.

Mammals did not show any positive relationships with characteristics of native vegetation. In fact, overall as well as guild wise species richness showed negative relationships with tree species richness. While the carnivores were marginally positively related to percentage of silver oak, number of fruit trees showed a negative impact on overall species richness as well as group wise species richness – both for generalists as well as specialists.

The fruit trees were abundant in all estates, especially the *Ficus* trees. *Ficus glomerata* and jack fruit (*Artocarpus integrifolia*) trees were present in high number in all coffee plantations. Even in estates with very high silver oak abundance, the planters essentially retained the *Ficus* species for a more permanent shade. The highest proportion of silver oak among the study sites was 52% in an estate which was adjacent to Bhadra forest and 43% in an estate which was 7.6 km from Bhadra forest. The number of mammal species recorded from these sites was 16 and 12 respectively. Hence, we could infer that at present the extent of silver oak in the plantations may not have crossed the critical limit to start impacting mammals.

Various studies have shown that coffee plantations with diverse vegetation are modified habitats with relatively high conservation value (Moguel & Toledo 1999; Petit & Petit 2003). Epiphyte, liana and bird diversity were found to be significantly high in shade coffee plantations in Indonesia due to floristic and structural diversity (Siebert 2002). Bird diversity is related to canopy height and structural complexity, which provides increased foraging and nesting sites (Greenberg et al. 1997) as well as floristic diversity that provides several food resources – fruits, nectar, and insects (Moguel & Toledo 1999).

However, the same need not be applicable to other taxa. Different taxa may respond differentially to different factors, depending on ecology of the focal group. Butterflies in

coffee plantations respond to micro-climatic conditions and availability of larval food plants (Horner-Devine 2003). Beetles depend on the soil moisture and availability of leaf litter (Badrinarayanan et al. 2003). In a study on mammals in coffee plantations in Mexico, Gallina et al. (1996) recorded 24 medium sized mammals and found the diversity and composition of mammals to be related to vegetation structure. But no large mammal was recorded and more than 50% of recorded species included fruit as part of their diet.

Large mammals that are essentially dependent on forests, such as tiger, sloth bear and sambar, may use coffee plantations only as feeding or resting sites, or for movement across the forest fragments. These animals generally have large home ranges and plantations adjacent to forests could be part of their ranges. For small to medium sized mammals with smaller home ranges that could be resident in coffee plantations, availability of resources throughout the year and reduced predation pressure are likely to be important factors rather than proximity to forests. This is evident in the lack of a negative correlation between species richness of the generalists and frugivores with distance from Bhadra. On the other hand, civet abundance was positively correlated with distance from forest, for unexplained reasons.

Most studies have looked at diversity of the focal group in shaded and unshaded coffee plantations (Perfecto et. al 1996; Moguel & Toledo 1999), where as in the Western Ghats, there are no unshaded coffee plantations. The closest in terms of shade comparison, is between coffee under mixed shade and coffee under monocultures of silver oak. But as stated earlier even the sites with highest proportion of silver oak had at least six *Ficus*. trees / km². In this scenario, since species diversity of mammals was negatively correlated to vegetation diversity, we can infer that there are other factors, which this study has not addressed.

Another constraint is that different species of mammals may respond to a wide range of factors differently depending on their ecology, life history traits and behaviour. Such relationships could be very species specific and therefore should be examined at the species level and not at the community level. For instance, among the large herbivores, two closely related species show contrasting response. While sambar was not recorded more than 800 m away from forest, chital was found to be resident in coffee plantations as far as 6 km from the closest forest.

The presence of many fruit trees coupled with the presence of a diverse fauna of insects and small vertebrates (birds, small reptiles, amphibians) in the coffee plantations (Perfecto et al. 1996) indicates the presence of potential food resources for mammals visiting and residing in these estates. The presence of trees in high densities for shade provides contiguous canopy cover for mammals. High abundance of keystone species such as *Ficus* provide important resource for frugivores mammals. Studies from elsewhere confirm the biodiversity potential of shade coffee plantations (Moguel & Toledo 1999) because of their location within species rich elevation in a biodiversity hotspot (Myers et al. 2000; Damodaran 2002; Perfecto et al. 2005). The future of conservation largely depends on the conservation value of human dominated landscapes, especially for mammals (Daily et al. 2003). The best approach to biodiversity conservation is through a variety of management approaches ranging from strict protection such as Bhadra Wildlife Sanctuary to intensive use such as coffee cultivation. Managing coffee plantations to address biodiversity concerns will both enhance productivity and contribute to conservation objectives.

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CHAPTER 2

Conservation in Coffee plantations: Implications of legislations, Local Practices and Awareness

Abstract

Coffee plantations occur as a matrix around several protected forests in the Western Ghats, and therefore are critical for biodiversity conservation in the region. Given the trend of conversions in shade from mixed to monocultures of silver oak *Grevillea robusta* and widespread hunting, this study focuses on legislations that directly or indirectly influence wildlife conservation in coffee plantations and conflict with local practices. The Karnataka Preservation of Trees Act, 1976 (KPTA) and Indian Wildlife (Protection) Act, 1972 (WLPA) were analysed with regard to their content and lacunae. The relationship between implementation of these legislations by the authorities and perceptions of the coffee planters and other stakeholders were examined, through structured interviews and group discussions. I found a lack of information and awareness among the planters regarding these legislations, and a lack of implementation from the Forest Department. KPTA seems to be inadequate to preserve native trees in coffee plantations. WLPA is limited to protection of animals within protected areas only and does not address the issue of extending protection outside it, even for critical landscapes like the coffee plantations. Planters elsewhere are voluntarily switching to 'green' and wildlife friendly practices for a better market access. Their proportion in the Western Ghats is very low, but there is a willingness to change if incentives are provided. In the Western Ghats monetary compensation can only address the indirect impacts on wildlife through presence of trees, and is inadequate to address more direct impacts such as hunting. I conclude that although the top down legislations and policies are necessary, they are not

adequate by themselves. A bottom up approach that focuses on changing attitudes through education and awareness would be more sustainable. Also, the Forest Department should recognize the conservation potential of coffee plantations and strengthen the implementation framework.

Introduction – What’s been brewing?

Coffee is the second most traded commodity in the world (International Coffee Organization 2001). Coffee produced in over 50 countries, mostly developing nations, provides livelihood to about 100 million people (Commerce Ministry of India 2005). Traditionally, coffee is grown as the understorey layer within an existing natural forest stand. Various studies from around the world suggest that such coffee plantations can harbor a wide variety of biodiversity compared to other commercial crops, because of the structural complexity of the habitat. Studies on insects (Perfecto and Vandermeer 1994, Perfecto et al. 1996), birds (Greenberg et al. 1997) and mammals (Estrada et al. 1993, 1994) support this.

In the past few decades, coffee production methods have seen fundamental changes, all over the world. Coffee production has accelerated in the last decade while coffee consumption has remained stable (O’Brien and Kinnaird 2003). As a result, global coffee production is at an all time high and prices have crashed leading to a global coffee crisis. This in turn has led to modernization of coffee cultivation in major coffee producing countries in order to increase yield and reduce cost of production. These changes have often been associated with a reduction in biodiversity (Gobbi 2000, Perfecto et al. 2005). This has serious repercussions for human livelihoods and biodiversity conservation (Siebert 2002).

In India, coffee is grown in the biodiversity rich Western Ghats. As mentioned earlier, the Western Ghats is a biodiversity hotspot of global significance (Myers et al. 2000). The coffee plantations form a matrix around protected areas or other forests, which are highly fragmented. This matrix provides a habitat for a wide variety of fauna and is also used as a feeding or breeding grounds (Kumar 2003). In addition, it also acts as a corridor, facilitating the movement of animals between fragments of forests (Janzen 1998). Coffee plantations

occupy an area of 355,000 ha (Coffee Board of India 2005), which is about 25% of total protected areas in the Western Ghats. Coffee plantations have contributed significantly to the fragmentation of the evergreen and moist deciduous forests in the Western Ghats and therefore are critical for biodiversity conservation in the region (Damodaran 2002). During a six months study, from December 2005 to May 2006 in coffee plantations in Chikamagalur district, Karnataka, a rich diversity of birds, butterflies and land mammals were recorded (Anand 2006, Dolia 2006, Bali current study).

In India, there are 178,308 coffee holdings out of which 98.4% fall within small growers category (<10 ha). The remaining 1.6% of these holdings, which come under medium and large categories, account for approximately 40% of total land under coffee (Coffee Board of India 2005). While the small planters receive various subsidies and financial assistance from the Coffee Board, the medium and large planters do not. This makes them more vulnerable to market fluctuations, and they may respond by changing management practices of coffee plantations. In India, the price decline in coffee began in 1997 and has accelerated from 2000 onwards. In 1997 coffee prices crashed from Rs.130/kg to Rs.56/kg for *arabica* variety and from Rs.56/kg to Rs.22/kg for *robusta* variety. This has led the planters to supplement their income by harvesting timber on a large scale to make up for losses in the coffee market. Subsequently they have been planting more fast-growing timber species for securing future income. Such management choices can profoundly affect conservation objectives in the Western Ghats in the future (Damodaran 2002).

Another factor that has a significant impact on wildlife in and around coffee plantations is the long tradition of hunting. Hunting is a cultural practice, which seeped in during colonial times and has continued through the generations (Elliot 1898). Since its enactment in 1972, the

Wildlife (Protection) Act has caused major changes in the way hunting is looked upon in the country.

This chapter focuses on legislations that directly or indirectly influence wildlife conservation in coffee plantations. The two pieces of legislation examined are (a) The Indian Wildlife (Protection) Act, 1972 and (b) Karnataka Tree Preservation Act, 1976. Both acts are analysed with regard to their content and lacunae. The relationship between implementation of these legislations by the authorities and perceptions of the coffee planters and other stakeholders are examined.

Study area and methods – Chikmagalur coffee: A whiff...

Coffee was introduced in India sometime during the early decades of the 17th century and first grown in Chikmagalur region in Karnataka (Anon. 1981). The British discovered a gold mine in coffee cultivation and developed it into a viable plantation crop (Elliot 1898). Coffee flourished amidst the biodiversity-rich hills of the Western Ghats. By the end of 19th century, the hill ranges of Karnataka, Tamilnadu and Kerala were covered with thriving coffee plantations. The British owned almost all the coffee estates in India till independence. When they left in 1940s, the plantations were taken over by local people.

Natives of Chikmagalur (then Kadur) are *Gowdas*. The two sects of Gowdas are *Vokkaliga* and *Lingayets*. The Vokkaligas are primarily meat-eaters and skilled hunters while the Lingayets are an essentially vegetarian community. These groups together constitute around 60% of the population of planters in the region. The Coorgs, Muslims and South Canara Christians constitute most of the remaining 40%.

In the last century, coffee has vigorously expanded and now dominates the plantations in the state. Today, Karnataka is the main coffee producing area in India accounting for 71% of total production, from 58% of total land under coffee cultivation in India. Out of the 1.6% of large land holdings, 75% fall in Karnataka. Over 43% of Karnataka's coffee growing area lies in Chikamagalur district, making it the largest coffee producing region in India. In addition, Chikamagalur region is the largest producer of *arabica* coffee, which demands 70% shade as compared to 40% shade for *robusta*. Hence, the density of shade trees is much higher as compared to rest of coffee growing areas.

A preliminary round of interviews with key-informants and a rapid review of applicable policies and legislations highlighted two aspects of coffee cultivation: a) positive impact on biodiversity in the form of presence of shade tree in high densities; and b) negative impact on wildlife due to wide-spread hunting. In this light, two legislations were identified as being most relevant, linking local practices and biodiversity conservation, namely: Karnataka Preservation of Trees Act, 1976 (KPTA) and Indian Wildlife (Protection) Act, 1972 (WLPA).

A second round of more comprehensive data collection was done through structured interviews and focal group discussions. These open ended discussions were focused around five general themes: (i) background information, (ii) description of cultivation and management practices, (iii) challenges faced by planters in coffee production and marketing, (iv) knowledge of existing State policies and legislations, and (v) attitudes toward the conservation of wildlife (including hunting). In addition, informal discussions were conducted opportunistically to get an understanding of the landscape and culture.

Data was collected through personal interviews and discussions with a total of 51 people in various categories. The respondents were carefully chosen to get representation of different groups. Around 50% of respondents were directly linked with coffee plantation. A total of 19 respondents were medium to large sized plantation owners, five were managers, and nine were labourers or from lower level staff category. Also, there were two Coffee Board representatives, three Karnataka Forest department representatives; three representatives of leading planters' associations namely United Planters Association of South India (UPASI) and Karnataka Planters Association (KPA), and representatives from two environmental NGOs actively involved in wildlife conservation and education in the region. Incidentally, many members and volunteers of the two NGOs were local coffee planters. In order to get better insights into the issues, eight people from non-plantation background were also interviewed. These included two academicians, two journalists, a lawyer, an auditor, a government land surveyor and a renowned wildlife photographer.

Through interviews and discussions, information was gathered on local policies (coffee management practices and cultural practices) and the awareness levels of planters with regard to the State policies (the two legislations – KPTA and WLPA). I have compared the practices against the objectives of the two legislations and tried to identify gaps. Based on my findings, I intend to make broad recommendations for a closer integration between management of coffee plantations and conservation interests.

Results

Tree conservation in coffee plantations: Shady Tales

Diversity of shade trees is one of the primary factors linked with greater biodiversity in coffee plantations (Gallina et al. 1996, Perfecto and Vandermeer 1994, Greenberg et al. 1997).

During the last few decades, coffee production in India has undergone substantial changes. From an environmental perspective, the most apparent change is the landscape level conversions in shade type from native wood species to non-native timber producing trees, such as silver oak *Grevillea robusta*, that provide an additional source of income (Perfecto et al. 1996, Damodaran 2002). Vegetation sampling in 14, medium to large sized coffee plantations revealed an average of approximately 30% silver oak trees in coffee estates, with some sites having even higher percentages. Conversions at such large scale may have long-term implication for conservation.

Silver oak is an exotic species, planted only for timber value. In a two-acre coffee plot (0.8 ha) one can easily plant around 300 silver oak trees. In 15 to 20 years time, these saplings can attain a girth of about 1 m, which can fetch an income between Rs.600,000 to Rs.700,000.

Native species that have high timber value are rosewood *Dalbergia latifolia* and teak *Tectona grandis*. Species such as rosewood can be harvested only with prior permission from the forest department. In addition to this, timber from these trees can be auctioned only through government owned timber depots and 33% of the revenue goes to government. Because of these restrictions, most planters are discouraged from planting these species.

Discussions with few old-time planters revealed another reason for silver oak being so widespread across the landscape. Before independence, coffee cultivation was limited to lower forested areas in the shola-grassland ecosystem of the Baba-budangiri range. As coffee cultivation became economically more attractive, it spread to the higher grasslands. Silver oak, being a fast growing tree, was promoted by the Coffee Board as a shade tree throughout

the 1960s and 70s. In 1976, the KPTA came into force and timber extraction from native trees became difficult.

A third generation coffee planter, who owns the only organic coffee farm in the district, pointed out that it was because of reservation of native trees, that more silver oak was being planted. He said, “Getting permission to cut one native tree takes ages, on the other hand, silver oak does not need permission from forest department to either harvest it or to transport”. Thus silver oak has become more widespread because it was promoted by the Coffee Board, and because harvest of native trees is complicated.

The Act

Karnataka Preservation of Trees Act, 1976.

The KPTA was passed to make better provision for preservation of trees in the State. It provides for the preservation of trees by regulating the felling of trees and for the planting of adequate number of trees to restore an ecological balance.

Here, ‘preservation of trees’ means, maintenance and protection of trees and prevention of damage, cutting or felling. ‘Felling a tree’ includes burning or cutting or girdling. It provides for appointment of a ‘Tree Officer’ and a ‘Tree Authority’, whose duty is to (a) ensure preservation of all trees within its jurisdiction; (b) carry out census of the existing trees; and (c) to specify the kind of trees which each locality and type of land should have. According to the Act, no person can fell a tree whether in his ownership or occupancy, without prior permission of the Tree Officer. However, the restrictions on felling a tree are not applicable on certain plantations and the exotic trees including silver oak.

The Act in practice:

Many medium to large planters interviewed were not aware of the regulations regarding the felling of trees. Most planters believed that the restrictions were limited to commercial exploitation of trees of native species. They believed that, if they did not sell the timber, they did not need any permission from the forest department to cut a tree on their property. This misconception has had a major role to play in the way the shade management is done.

Shade management is an annual exercise of thinning of the shade before the monsoon to ensure that coffee bushes receive sufficient sunlight during the monsoon. Generally it involves lopping of branches of shade trees and occasionally removal of a few trees. It was a fairly common practice to cut a tree irrespective of the species without the forest department's permission. The managers reported that trees census had never been conducted in the estates, hence there was no way that the forest department could find out about this action. Often trees were killed by girdling. Lopping of branches more than 10 cm girth is not allowed, but no one followed this regulation or even knew about it. When I asked one estate manager about this rule, he replied- "I did not know about it. No letter came from the government regarding this ever. But no need to worry as no officer will come to check in the estates".

A well informed planter said that, in 1999, timber was harvested in huge amount, including jungle wood (native species) because of losses in the coffee market. Due to bureaucracy, planters received less returns on the harvest of native species. As a result they harvested greater quantities.

The most interesting response came from an elderly owner of a very large plantation. He believed that KPTA was applicable to only Kodagu district. "There is a totally different

procedure for timber harvest... one just needs to bribe the ACF and ranger and in case of valuable trees like rosewood, give them their fixed share of the timber”, he explained to me.

Silver oak is exempt from the reservation and is grown purely for monetary considerations. There is a total lack of information and awareness among the planters regarding the existing law. Furthermore, there is also a lack of implementation from the Forest Department. Given the fluctuations in the coffee market, KTPA seems to be inadequate by itself to preserve native trees in coffee plantations.

Hunting: Practice Imperfect

Hunting was wide spread in the region as revealed by most respondents. There are two distinct categories of hunters, namely the estate labourers and villagers, and the planters themselves. There are differences in the way these two groups hunt as well as the reasons for which they hunt.

Plantation labourers and villagers hunt for food as well as for supplementary income. The daily wage of a coffee estate labourer ranges from Rs.65 to Rs.72, while the price of meat is Rs.140/ kg in the local market. Many plantations, especially those that are very close to Bhadra Wildlife Sanctuary, are also far from the nearest town. In such areas, hunting is a matter of opportunistic convenience. It is a common practice for labourers to put snares for catching hare as well as wild boar, to smoke porcupine burrows and flying squirrel nests in tree holes and to catch civet kittens from tree trunks especially during shade lopping. A group of plantation labourers revealed over an informal chat that though ‘*harbeku*’ (flying squirrel) was very tasty, it had very little meat, so one needed to get at least 3-4 animals for a good meal; that ‘*cupbeku*’ (common palm civet) meat was palatable only before winter and post-

winter, the animal's diet gave a bad odor to the meat; that sambar meat was very 'chewy' and that they would prefer a muntjac anytime; that it was easy to catch mouse deer - it only had to be chased down a slope and it choked itself and one just needed to go and pick it up. In addition to hunting for food, certain animals such as lizards, snakes and civets are occasionally poached for skin.

The planters hunt mainly for sport. These hunts are organized for a group of 10 to 15 or more people. They use guns, four-wheel drive vehicles and powerful spotlights. Hunts are usually organized as a 'night out' for men-folk on occasions of celebration – during festivals like *Gauri-Ganesh* or Id; to celebrate New Year or good rains; and even when coffee prices go up.

The only woman planter respondent assured me that there was no more hunting in the region. She explained that in olden days (until 20 years back), estates were located very far from towns and villages. Meat and poultry were not available everywhere and the planters seldom left their estates. Hence hunting was a common practice to be able to survive in those jungles. Now the circumstances had changed and people feared the law. She also remarked that hunting of wild boar for crop protection as well as snaring of hare for food by their laborers did not count as hunting and was not illegal.

A representative of a local wildlife conservation group pointed out that hunting by labourers was seldom for subsistence. If the plantation owner did not prevent his workers from hunting inside the estate, they would hunt whatever animal they might find. It was mostly opportunistic. Small animals and birds were easy target as they were available everywhere, wild boar being the most preferred species. Very often, large herbivores were also not spared. Then, there were some small planters, who would go and hunt in other estates in groups. A

respondent from a local village told that, during festival if one tried to stop these hunters from getting into their property, they might retaliate by setting the estate on fire. In addition to hunting in coffee plantations, sport hunting takes place mostly in small patches of reserve and revenue forest adjacent to the plantations.

An owner of a medium sized coffee plantation remembered his old times – “Those days we used to get plenty of animals around the estate itself. I, along with my brothers and neighbors would go hunting at least once every fortnight. Those days we used to get plenty of sambar, chital and wild boar”. He moved to Chikmagalur town in 1986 and since then he has not gone hunting. While his old time hunting partners, who continue to stay on the estates still hunt. He added, “but my share from the hunt is still sent to my home on all hunting occasions. When you are part of a hunting group, you are ‘in’ even when you are absent. While the members get around two and a half to three kg of meat, even the hunting dogs brought along get their share. Now a days, it is mostly wild boar meat; occasionally sambar or barking deer, and once in a while a chital if you get really lucky”. On asking about the frequency of this ‘share’ he told it was usually once a week, but one could safely count approximately 40 weeks a year. He also added that till date his hunting group had never been caught by forest department. He agreed that hunting had surely decreased as compared to old days, but so had the game.

According to a database maintained by another local wildlife conservation group, which is actively involved in combating poaching in Chikamagalur district, there are total of 71 big and small hunting groups are active in the district. A representative from this organization while trying to highlight the severity of the issue informed that “on an average, these groups organize hunts twice a month. For a 15 member hunting party, where per head share is 2.5 to 3 kg meat; they need to kill at least two to three large mammals during a single hunt”. If this

were true, the most conservative estimate leads to a figure of at least 142 large mammals being hunted every month, or at least 1704 per year in the district. In addition to this numerous smaller animals such as mouse deer, civet, cat, hare and birds are regularly hunted.

In contrast, the number of hunting cases booked by Forest Department told a different story. According to their records, in last five years, only 19 cases have been booked for wildlife offences taking place outside Bhadra Wildlife Sanctuary and only on four occasions were arrests made. Last year, a single case was booked for sambar hunting.

The Act:

Indian Wildlife (Protection) Act, 1972.

Wildlife (Protection) Act, 1972 (WLPA) is a criminal law that provides ways to deal with offences related to wildlife. Also, it is a land acquisition law that is instituted to facilitate the creation of protected areas. In addition, WLPA is a natural resources management law that controls land and resource usage pattern in the Protected areas, which in turn is related to the conservation and protection of endangered species (Dutta 2004).

The definition of wildlife in the Act is very broad, extending to both flora and fauna. There are six schedules appended to the text of WLPA, containing a list of species protected by it. Schedule I and II include most endangered and threatened animals of India. 'Wild animal' is any animal that is (i) listed in Schedule I to IV of the WLPA and (ii) is found in nature. As per provisions of WLPA, all wildlife is protected only in national Parks and Sanctuaries (Dutta 2004).

In the region, most of the hunting was done outside the Bhadra Wildlife Sanctuary. All the respondents were aware of the risk and consequences of hunting inside the Sanctuary. They also understood that hunting in the reserve forests and revenue forests as well as in the coffee plantations did not have same risk.

The Act in practice:

In spite of its many provisions, the act is not a comprehensive code in itself. For example, hunting of any wild animal specified in Schedule I, II, III and IV is an offence (sec 9, WLPA) but basic procedures such as arrest, search and detention, outside the Protected Area, are not provided for in the WLPA; and depend entirely on the policing system. A lack of clarity still exists about the interpretation of its many provisions (Dutta 2004).

WLPA does not address the issue of extending protection to animals outside the protected areas, especially in a landscape like the coffee plantations. The protection is limited to a designated area. Outside the protected area, Forest Department's job is limited to booking cases, that too if it gets reported. The Forest Department will take action only if informed of the offence. One of the respondents remarked, when asked about the role of the forest department in controlling hunting in coffee estates, "It has come in our blood. No law can prevent us from hunting. This habit will go only through a gradual process of education." He believed that NGOs had a greater role to play than forest department.

A member of a locally active environmental organization reiterated the same view. He believed that the reduction in hunting was not because of strict enforcement of WLPA or reduction in animal abundance. It had been possible because people had better access to education. The younger generation was losing interest in hunting as well as hunting skills. He

believed that it was very difficult for the Forest Department to deal with poaching even inside Bhadra WLS. They are incapable of handling situation outside protected areas given the resources and staff strength. In his opinion, forest department was not using the WLPA effectively. Another young planter and an active member of the wildlife conservation NGO remarked that it was because of the presence of environmental NGOs in Chikmagalur district that the younger generation of planters were more inclined towards appreciating nature than destroying it. He added that it was not the WLPA that threatened them. Loss of reputation was the biggest fear, not the fine or punishment.

An old time hunter who has now replaced camera for a gun remarked, “Shooting is banned. But no monitoring, therefore a lot of poaching goes around”. After coffee picking gets over, he sends his watchman to check for snares that his labourers often set all over the estate to catch hares and wild pigs. Another planter who had banned hunting on his estate said that many planters tried to prevent hunting on their estates but that was not sufficient. The Forest Department needed to be more proactive and supportive of them.

No wild animal listed in Schedule I to IV of WLPA can be killed, irrespective of its location. Coffee plantations come under the purview of WLPA. But hunting goes on in these private properties without forest departments’ obstructions. A senior level staff of the forest department remarked, “Bhadra Wildlife Sanctuary is full of animals to its capacity. Because of competition for space and resources, the old and weaker ones get booted out into the coffee plantations. If they cross their designated territory and enter human territory, they deserve to be killed. What can we do about it?” Another senior forest officer explained their inability to patrol outside the Sanctuary for lack of resources. He said that they could act only if they were informed about any crime taking place outside the Protected Area.

WLPA talks about protecting areas as a means of protecting wildlife. Why is it that despite featuring in the Schedule I, a sambar loses its importance when it crosses the boundary of the protected area to the very department that is supposed to protect it? In all its practicality, WLPA is limited to protection of animals within protected areas only. By itself, it is not comprehensive enough to ensure overall conservation of biodiversity.

Discussion – The cup that could cheer!

The very legislation that intends to preserve native trees is responsible for encouraging planters to grow more exotic silver oak. There is very low awareness about the regulation among the planters and some corruption too among the Forest Department. In the case of wildlife conservation, hunting seems rampant. Though WLPA is applicable, it seems to have very little impact outside Bhadra Wildlife Sanctuary. Lack of resources is one reason expressed by the Forest Department; another reason is the perception that policing outside formally protected areas is just not their job. Hence, due to market failures as well as inappropriate policies, the biodiversity of Western Ghats has been continuously declining (Ninan and Sathyapaan 2004).

However, some planters are switching to eco-friendly practices, independent of the State policies for preservation of native trees or wildlife conservation in the region. Some local planters who recognize the economic risks associated with monoculture shade grown coffee and are increasing the density and diversity of trees in an effort to provide shade and organic matter. A side effect of this is better conditions for supporting biodiversity in coffee plantations.

An owner of a large coffee plantation said that he had learnt from repeated soil testing that in a pure silver oak stand, over a period of few years, the soil can become deficient in important micro-nutrients. Silver oak leaves do not degenerate fast and increase soil acidity. He revealed that he was reducing density of silver oak in his estate by planting more native species as per the suggestions of his European buyer. On the other hand, a majority of planters, despite being aware of the ecological problems associated with silver oak, are not motivated to grow native trees unless offered a premium for their efforts. Every planter expressed willingness to change their management practices as well as confer protection to wildlife in his estate if he got incentives. It could be in the form of incentives from Coffee Board and subsidies from Government for coffee production, or a higher price and increased market access for the coffee itself.

Globally, there has been an increase in awareness about the environmental links to coffee. This is true for all stakeholders – producers, marketers and consumers. Producer organizations are beginning to address coffee's environmental aspects by adopting eco-friendly ways. The slogans range from 'pesticides-free' and 'grown under native shade' to anything 'green' (Anon. 2004, Conservation International 2001). Marketing strategies based on organic coffee as well as bird and biodiversity friendly coffee have been very successful in other countries (Rappole et al. 2003, Conservation International 2001). Consumers are being offered range of coffee being produced under variety of systems. Targeting consumers with environmental concern, 'wildlife-friendliness' could be a useful way to capitalize on their sympathy to provide the 'premium' or incentive to the coffee growers.

In Western Ghats, if this approach is adopted and a framework is designed to give monetary rewards, would this ensure the conservation of trees and animals in coffee plantations? The

indirect impact on animals through removal of native tree can be taken care of by giving monetary compensation. But, would subsidies make any difference to the expression of male attitude of celebration through hunting?

Changing habits and attitudes is a long process. A lot needs to change at a social level for the society to change their practices. Legislations and policies help but education can play a bigger role than poorly grafted and implemented legislations. Also, new methods for regulation are needed. There is a strong need for awareness-raising among the society, especially among the people whose livelihood has such direct and strong links with nature.

“Conservation generally has been based on the idea of sequestering the largest possible tracts of nature in a state of imagined innocence as national parks and other protected areas” (McNeely 2004). However, there is always a lack of resources for conservation, especially in the developing countries in the tropics, which are incidentally very rich in biodiversity. While the ethical and moral grounds can be advanced to justify wildlife conservation, it is principally the economic forces that constrain the actions (Ninan and Sathyapalan 2004). The future of conservation, therefore, largely depends on conservation value of human dominated landscapes, especially for mammals (Daily et al. 2003). We tend to find solutions in economics or state policies. This approach needs to be questioned.

In my opinion this is an issue of attitudes and habits. The top down legislations and policies are necessary, but are not adequate by themselves to make any difference. The change would be sustainable only if it emerges bottom up. Attitudes change as a result of combination of a variety of forces – culture, economics, policies, politics and so on. Change is a long and protracted process. But to start off with, there is grave need of recognition from the Forest

Department and the Coffee Board that there is enormous conservation opportunity in the coffee plantations.

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