THE ECOLOGICAL IMPACTS OF TOURISM IN PROTECTED AREAS IN KARNATAKA

Case studies from

Bandipur, Bhadra & Dandeli-Anshi Tiger Reserves

Final project report

submitted to

Karnataka Ecotourism Board

&

Karnataka Forest Department

by

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Chapter 1. **Introduction**

An Overview

Tourism has increased by more than 100% between 1990 and 2000 in the world's biodiversity hotspots, regions richest in species and facing extreme threats (Christ et al. 2003). The distinguishing feature of ecotourism should be that it benefits biodiversity conservation (Brandon & Margoulis 1999). Although nature-based tourism (often incorrectly called eco-tourism), a growing economic sector in India, does generate economic support for conservation (Karanth & DeFries 2011), the ecological fallouts of these activities are seldom examined. Furthermore, policy and regulations pertaining to such tourism is either absent or drafted based on little to no understanding of the actual workings of the ecology or socio-economics of nature tourism activities. Existing policy is often incorrect or limited in its view of impacts, and inadequate to curb or mitigate real impacts. The need for a deeper, empirical understanding of the ecological ramifications of activities and infrastructure centred on nature tourism is urgent.

Recognizing this need, the Government of Karnataka – Karnataka Ecotourism Board and Karnataka Forest Department – has made a preliminary effort to garner a broad and very basic understanding of the effects of tourism on biodiversity in 3 protected areas in Karnataka –Bandipur Tiger Reserve, Anshi-Dandeli Tiger Reserve, and Bhadra Tiger Reserve – in order to advise a basic state-level, site-specific tourism policy for these areas. This preliminary work would also identify the scope and nature of a long-term, landscape-scale study to elucidate the ecological (together with economic and environmental) underpinnings of the nature tourism industry in the state, which boasts several high profile protected areas which are visited by lakhs of tourists each year.

In general impacts can only be detected as a change relative to a prior baseline (Buckley 2003). However, as in the case of most protected areas in India that experience pressure from tourism, pre-tourism ecological baselines are not available. In such cases, determining impacts would consist not of comparing levels of a given variable/indicator to the pre-tourism baseline but comparing them across areas with and without tourism. In each of the sites included in this study, the state forest department has clearly demarcated a zone within which tourism activities, such as safaris, interpretation walks, and trek, may be conducted. These zones are generally less than 10% of the total area of the protected area and for the purpose of this report will be referred to as "tourism zone". The rest of the protected area, referred to here as "core zone" are generally devoid of tourist activities. Thus, by comparing forest vegetation structure and composition, as well as wildlife habitat

use across these two zones (all else being equal), one might gain a broad and coarse picture of the differences in these variables, presumably wrought by tourism.

Methodology

We investigated the impacts of tourism, specifically safaris, on 3 ecological aspects – habitat (plant communities), prey (ungulates), and predator (large carnivores). We employed different but overlapping sampling methods for each of these aspects. We used nested plot-sets to describe vegetation and ungulate relative habitat use, and line transects to quantify relative large carnivore habitat use.

VEGETATION & UNGULATES

We marked equal numbers of plot-set locations in the tourism and core areas. Plot-sets were located in forests that were similar in topography, rainfall, and forest type so that any difference in the measured variables may be generally attributed to the presence/absence of tourism. Each plot-set was located along a road (no less than 10 m from the road, and no greater than 20 m from it) and was at least 2 km from any other plot-set (so as to reduce spatial auto-correlation). Each plot-set consisted of nested plots within each of which we quantified a different stratum of the vegetation community. In the largest plot of the set we also quantified ungulate habitat use using a faecal-group count.

10-m radius

- Adult trees – Size (Girth at Breast Height – GBH), number and species of all adult trees (> 15 cm in GBH), live as well as dead (snags and logs).
- Ungulates – Number of faecal groups (pellet groups as well as dung) of all ungulates (mouse deer, barking deer, chital, sambar, gaur, and livestock) found in the plot.

5-m radius

- Tree saplings – Height, number and species of all tree saplings (<15 cm in GBH, > 50 cm m in height).
- Forbs – Number and species of all adult herbs and shrubs (> 50 cm in height).

1-m × 1-m quadrat

- Tree seedlings – Height, number and species of tree seedlings (< 50 cm tall).
- Forb seedlings – Number and species of herb and shrub seedlings (< 50 cm tall).
- Grass – Percentage of grass cover in the quadrat, average grass height, and number of grass species.

Field team quantifying vegetation (tree seedlings, forb seedlings and grass) in a 1-m × 1-m quadrat nested within the larger 10-m radius plot

Based on these data we conducted a simple t-test to determine whether there is a statistically significant difference in any of these vegetation/wildlife variables between tourism and core zones.

LARGE CARNIVORES

We selected 2 pairs of independent roughly equal lengths of road (between 4 and 5 km each), each pair having 1 transect in each zone. We walked each of these transects 3 times (on 3 separate days as early in the morning as possible). The first time we noted all sign of tiger, leopard and dhole (scratching, scent-marking, scats and tracks). The second and third times we noted only new sign (sign that had been left since the previous time the transect was walked). We calculated sign encounter rate for each species as the number of signs of each species encountered per kilometre of transect walked. We then used a simple t-test to compare sign encounter rates for these carnivores across tourism and core areas to get a very general sense of difference in habitat use by these species across these zones.

Large carnivore habitat use was sampled by walking transects (approximately 5 km in length) along roads. All sign – scats, tracks and scent-marking scratching – of all three species of large carnivores (tiger, leopard and dhole) was noted.

Case studies

Using the same vegetation and wildlife habitat use sampling methodology, described above, we surveyed the effects of tourism in each of the three sites selected to be case studies. The three sites selected for this pilot study vary not only ecologically but in the quantity and type of tourists that they attract.

Dandeli — At the low end of the spectrum, Dandeli-Anshi Tiger Reserve is truly off the beaten track and attracts only the most keen of nature lovers and outdoor sportsmen. Most visitors to Dandeli come to do white-water rafting. Tourists come to experience the forest may stay at Jungle Lodges and Resorts (JLR) and take their safari. Those that stay in other accommodations may take the safari operated by a local village ecodevelopment committee. These are the only 2 jeeps/safaris that ply in the forest. **Tourism pressure inside Dandeli is low.**

Bhadra — Tourism occurs on two sides of this Reserve – Muthodi and Lakkavalli. Most of the tourist facilities on the Muthodi side of Bhadra (close to Chikmagalur) cater to tourists who come to experience the ambience of homestays on coffee estates and trekking in the Bababudangiri mountains. Very few of these visitors are interested in visiting the Tiger Reserve. At the time of the study there were no safaris being conducted in this range. On the Lakkavalli side of Bhadra tourists interested in viewing wildlife may stay at JLR which offers regular morning and evening safaris. Being a 5-hour drive from Bangalore, only those keen on experiencing the forest and viewing wildlife visit Lakkavalli. Yet proximity to Bangalore, Mysore and Shimoga, relative to Dandeli, results in a greater volume of visitors to Bhadra when compared to Dandeli. **Tourism pressure in Bhadra is medium** (greater than Dandeli but less than Bandipur).

Bandipur — Bandipur has, by far, the greatest number of tourists. These tourists may be either incidental or specific. Incidental tourists are those who stop in Bandipur on their way elsewhere. Not only located close to Mysore, Ooty and Bangalore, the highway connecting these cities also passes through Bandipur. Consequently, visitors to Bandipur includes a large number of travellers who stop at Bandipur simply because it is en route and offers some entertainment. Specific tourists are those who come to specifically to Bandipur from around the country and world to view wildlife and enjoy 'nature'.

The large volume of people who visit Bandipur necessitates large numbers of safari vehicles taking people into the forest at regular intervals. Consequently, Bandipur also experiences arguably the greatest safari pressure of any protected area in the state. Over a dozen vehicles – both jeeps and mini buses – operated by the Karnataka forest department as well as Jungle Lodges and Resorts (JLR) drive around the tourism area of the Reserve twice a day. Several resorts, hotels and other types of tourist accommodations and facilities are to be found along the boundary of the Reserve in 2 clusters (Melkamanahalli cluster along the main Mysore-Ooty highway, and the Mangala cluster). **Bandipur, therefore, is classified as a high tourism-pressure PA**.

In the coming chapters the findings of this preliminary study on tourism in these PAs will be presented. Each protected area examined will be presented as a case study because each is different in the nature attraction that draws tourists, the scale of the tourism that occurs there and the socio-economics of the surrounding matrix. Owing to differences in the volume and type of tourists they attract we expected each site to have different responses to safaris. The details of each site and the methods used are described in subsequent chapters. In Chapter 2, 3 and 4 the studies conducted in Bandipur, Dandeli and Bhadra respectively are described and results presented. In the final chapter we draw broad conclusions pertaining to all three sites and to eco-tourism practice in general.

Chapter 2. **Bandipur Tiger Reserve**

Introduction

Bandipur Tiger Reserve (BTR; 880 km^2; 11°57′ N, 76°12′ E - 11°35′ N, 76°51′ E; Fig. 2-1) in the foothills of the Western Ghats, runs east-west along the rainfall gradient in the region. The western portion of BTR lies in the foothills of the Western Ghats and receives the heaviest rainfall of the Reserve whereas the eastern portion lies largely in the rain shadow and receives relatively little rain. Dry and wet seasons are distinct, each lasting approximately 6 months (dry, January to June, wet, July-December). Fires are common in the early dry season between January and April. In the dry season, trees shed their leaves, and flush soon after the pre-monsoon rains.

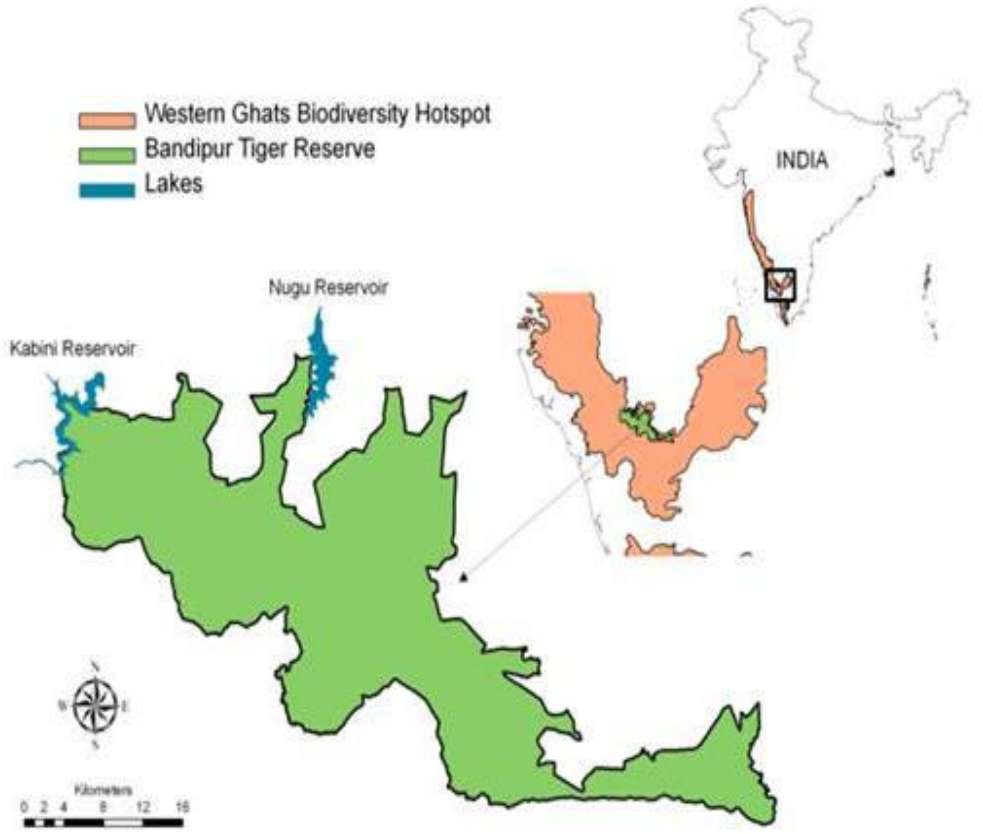

Figure 2-1. Bandipur National Park and Tiger Reserve, located in the Western Ghats biodiversity hotspot in peninsular India, is dominated by tropical moist and dry deciduous forest, and is of one India's most visited wildlife areas.

Flora

As a result of the wide rainfall range within the Reserve, forest vegetation type also varies east-west. The eastern-most areas are thorn-scrub, and open savannah type vegetation, dominated by *Themeda cymbaria* (Andropogoneae) tall grass interspersed with *Anogeissus latifolia* (Combretaceae), *Randia dumetorum* (Rubiaceae), and other tree species. Further west, the open scrub forest gives way to dry deciduous vegetation dominated by the canopy species *A. latifolia*, *Tectona grandis* (Verbenaceae) and *Terminalia* spp. (Combretaceae). *Grewia tiliaefolia* (Tiliaeceae), *Kydia calycina* (Malvaceae), *Phyllanthus emblica* (Euphorbiaceae), *Stereospermum personatum* (Bignoniaceae), and *Schrebera swietenoides* (Oleaceae) are also common. In the western-most region, the forest retains some of the dry forest species (primarily *Anogeissus, Terminalia*, and *Tectona*) which attain greater height and girth. In addition, moist and semi-evergreen forest species such as *Adina cordifolia* (Rubiaceae), *Mitragyna parvifolia* (Rubiaceae), *Schleichera oleosa* (Sapindaceae), *Terminalia arjuna* (Combretaceae), *Pterocarpus marsupium* (Fabaceae), *Lannea coromandelica* (Anacardiaceae) and *Dalbergia latifolia* (Fabaceae) occur more frequently. Randia, Phyllanthus, and Anogeissus, are less common in moist forest than in dry forest. Low-lying, waterlogged short grass forest is dominated by *Randia uliginosa* (Rubiaceae) and *Careya arborea* (Lecythidaceae). Riparian areas are bamboo-dominated (*Bambusa arundinacea*; Poaceae), and have evergreen trees such as *Mangifera indica* (Anacardiaceae), *Syzygium cuminii* (Myrtaceae), and Ficus spp. (Moraceae). Understory vegetation also changes from east to west, with scrub and savanna understory in the east consisting mainly of tall grass, and thorny species such as *Zizyphus* spp. (Rhamnaceae), *Canthium parviflorum* (Rubiaceae) and Randia spp. (Rubiaceae). The dry and moist forest understory is also tall grass-dominated but thorny species become less frequent and *Indigofera* sp. (Fabaceae), *Helicteres isora* (Malvaceae), *Grewia* spp. (Tiliaceae), and *Holarrhena pubescens* (Apocynaceae), dominate the understory. In recent years, however, BTR (together with other deciduous forests in the region) has been extensively invaded by exotic plants, such as *Lantana camara* (Verbenaceae), *Eupatorium odoratum* (Asteraceae), *Ageratum conyzoides* (Asteraceae) and *Parthenium hysterophorus* (Asteraceae). In several places, these exotic plants appear to have replaced native understory species. Of these exotic plants *Lantana camara* is the most abundant (in areas of severe invasion, over three-fourths of the understory biomass is comprised of *Lantana*; A.E. Prasad unpublished data).

Fauna

The terrestrial mammals of BTR represent several families – rodents, herpestids, lagomorphs, primates, ungulates, proboscids, and carnivores. While several small rodents occur here (genera Mus, and Rattus predominantly), the largest rodent is the Indian

porcupine *Hystrix indica*. The only lagomorph is the black-naped hare *Lepus nigricollis*. Two species of primates occur here, the bonnet macaque *Macaca radiata* and the common or Hanuman langur *Presbytis entellus*. The occurrence of the third primate is debatable as only occasional and untenable reports of the loris *Loris lydekkerianus* have been made. Altogether six species of ungulates are found in BTR – two bovids, (four-horned antelope *Tetracerus quadricornis*; and the Indian gaur *Bos gaurus*) and three cervids (barking deer or common muntjac *Muntiacus muntjac*; chital *Axis axis*; sambar *Cervus unicolor*), and one tragulid (mouse deer or chevrotain *Tragulus meminna*). The small carnivores are mostly the small felids (jungle cat *Felis chaus*; leopard cat *Prionailurus bengalensis*; and rusty-spotted cat *Prionailurus rubiginosus*), viverrids (such as common palm civet *Paradoxurus hermaphroditus*), and herpestids (the mongooses - common *Herpestes edwardsii*; stripe-necked *Herpestes vitticollis*; and ruddy *Herpestes smithii*). The golden jackal *Canis aureus* has also been reported from this area. The large carnivores of the Reserve are the tiger *Panthera tigris*, leopard *Panthera pardus* and the dhole or Asiatic wild dog *Cuon alpinus*.

Human presence in Bandipur Tiger Reserve

BTR is unique because there are no human settlements within it, as there are in most other protected areas of India. Despite this, however, the forest is not free from anthropogenic pressures. Forest biomass harvest via Minor Forest Produce (MFP) collection, fuelwood harvest and livestock grazing from approximately 150 agropastoral settlements along the northern boundary of the Reserve continues to occur. Fuelwood extraction and livestock grazing are particularly severe being both chronic and intensive. Over 150 tons of fuelwood are extracted from the Reserve daily (close to 55,000 tons annually; M.D. Madhusudan, unpublished data) from areas within 5 km of the forest boundary with settled land. Further, over 100,000 livestock (mostly *Bos taurus*) from these villages graze up to a distance of 5 km into the Reserve and have been shown to severely reduce wild herbivore densities and drastically alter vegetation abundance and composition (Madhusudan 2004). In addition to these threats to forest biota from dependent communities, management-related activities are also widespread. The creation of roads, fire-breaks, and waterholes, together with controlled burning could be exerting a plethora of unknown effects. Finally, exotic plants have spread extensively through the forest understory, probably facilitated by these disturbances (Hobbs 1989; Hobbs & Huenneke 1992; Blumenthal 2005) and with little known impacts on native species.

Tourism in Bandipur Tiger Reserve

BTR is one of India's most popular wildlife-viewing destinations. Its proximity to the major cities of Bangalore, Mysore, and Ooty make it accessible to wide variety of tourists, ranging

from those who stop at Bandipur on their way between these cities, out of curiosity, to those who make one-day excursions from these cities to 'picnic' and 'enjoy nature' to those who come to spend more than a day watching birds, looking for larger wildlife, especially tigers, and doing wildlife photography (a new and rapidly growing demographic of tourists). Tourists who stay at least one night have the option of government dormitories and cottages at Bandipur as well as a wide array of private accommodation facilities (resorts, lodges and homestays) located outside BTR. Although trekking is currently not allowed in BTR, safaris are open to all tourists who wish to enter the Reserve in order to view wildlife. There are two basic types of safaris – (i) the high-end open jeep (Mahindra or Maruti Gypsy) safaris that cost a minimum of Rs. 2000 per head, offered both by Jungle Lodges and Resorts (hereafter JLR) as well as the Karnataka Forest Department (hereafter KFD) and (ii) the relatively inexpensive mini-bus safaris offered only by the KFD. These jeep and mini-bus safaris run both morning (approximately 6:30 to 9:30) and evening (3:30 and 6:30) and their frequency and occupancy depends upon season and tourist visitation. Safaris run in a specifically designated tourism area which is about 35 km^2 in area and is located in the vicinity of Bandipur camp, on both sides of the Mysore-Ooty highway that runs through BTR. This small area (> 5% of the Reserve's area) has a very high density of roads (2.25 km/km^2), a network that is designed and maintained to maximize wildlife sighting frequency in the safari zone. These safari roads are bordered by view-lines, clearings that run along both sides of roads and increase visibility for viewing wildlife, and are 30-40 m wide. View-lines are maintained by cutting and burning understory vegetation at least once a year, but sometimes more often depending upon how quickly the clearing is overgrown by *Lantana*; trees are left standing. Furthermore, waterholes (both natural and manmade), check-dams, clearings and salt-licks are regularly maintained throughout the year in order to 'improve' the habitat for large wildlife (mainly ungulates, elephants and large carnivores), and attract them to the area where tourists have higher probability of spotting them. We expected that the combination of high road density, greater vehicular traffic, and the management/modification of forest increase wildlife sightings would lead to differences in vegetation, large herbivore and large carnivore communities between safari (tourism) and non-safari (core) forest.

Methodology

Details of methodology followed are given in the Introduction (page 6-7). In Bandipur we marked and sampled 25 locations for vegetation and ungulate habitat use, in the tourism and core areas (N = 50). For sampling large carnivore habitat use we walked two pairs of transects –one pair consisting of one 3.93-km transect in the core zone and one 4.18-km transect in the tourism zone, and the second pair consisting of two 5-km transects – each three times, for a total of 54.33 km of transect walked.

Results

VEGETATION

Certain strata of the forest vegetation community in BTR showed marked differences between core and tourism zones. They are:

Tree density — The core area plots had significantly more trees per plot than tourism area plots ($F_{1, 48} = 4.598$, $p = 0.037$ Figure 2-2). This could be because (a) more trees in the tourism area are dying (b) few individuals are being recruited into the tree size class, or (c) both. Tree size (GBH) did not differ significantly between tourism and core areas. That is, both areas have similarly sized trees.

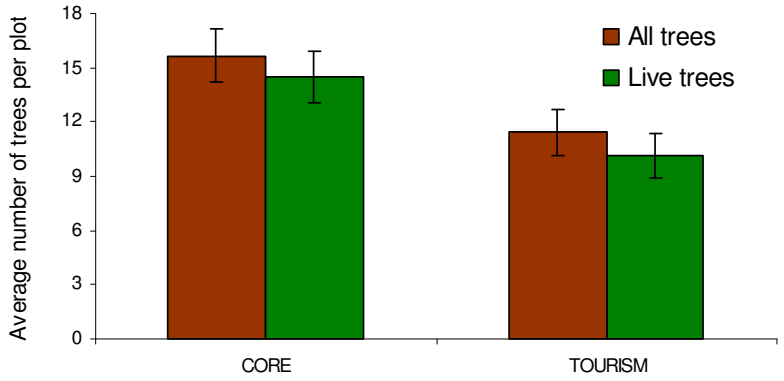

Figure 2-2. Density of live and all trees as determined from 50 circular plots of 10 m radius in Bandipur Tiger Reserve

In order to explore whether above option (a) i.e., increased tree death in the tourism area, might explain this difference in tree density, I compared tree death in both areas. The tourism area had a higher dead tree to live tree ratio (tree death) than the core area (Figure 2-3). However, this difference was not significantly different ($F_{1, 48} = 2.264$, $p = 0.139$).

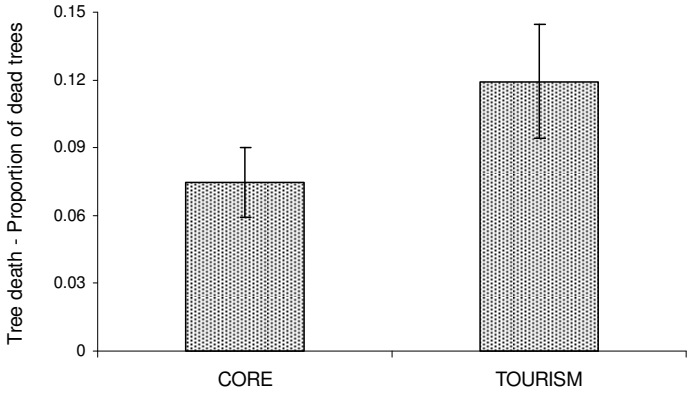

Figure 2-3. Tree death (ratio of dead trees to total trees per plot) in the core and tourism areas of Bandipur Tiger Reserve as determined from data in 50 circular plots of 10 m radius

Tree species richness — However, core area plots had, on average, one more species than tourism area plots (Figure 2-4) which does not seem much but is a statistically significant difference, nonetheless ($F_{1, 48} = 4.847$, $p = 0.032$).

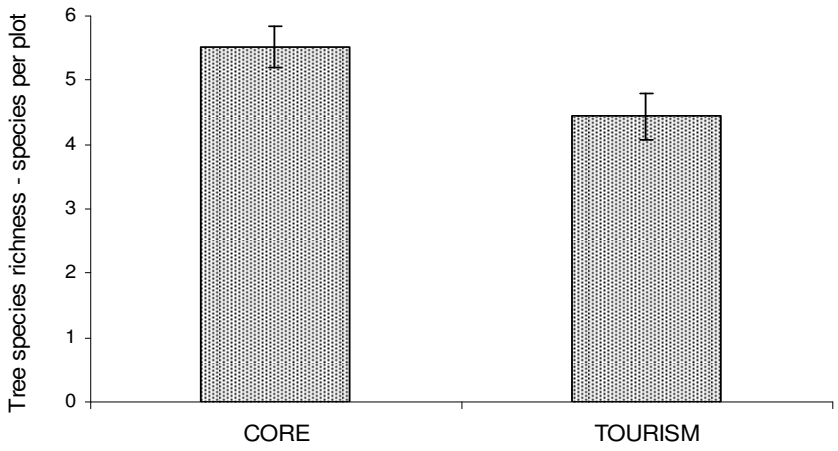

Figure 2-4. Average number of tree species found in the core and tourism (safari) zones of Bandipur Tiger Reserve

Tree sapling density — Although mean sapling density in core area plots was higher than tourism area plots, this difference is not significantly explained by tourism ($F_{3, 42} = 1.592$, $p = 0.214$) after the effect of tree density (Figure 2-5; $F_{1, 42} = 19.510$, $p < 0.01$) and *Lantana* biomass (Figure 2-6; $F_{2, 42} = 4.635$, $p = 0.037$) are accounted for. This suggests that being in the tourism or core zone per se does not explain differences in sapling density. Rather, it is factor associated with zone, differences in tree density and *Lantana* biomass, that may drive tree sapling density differences.

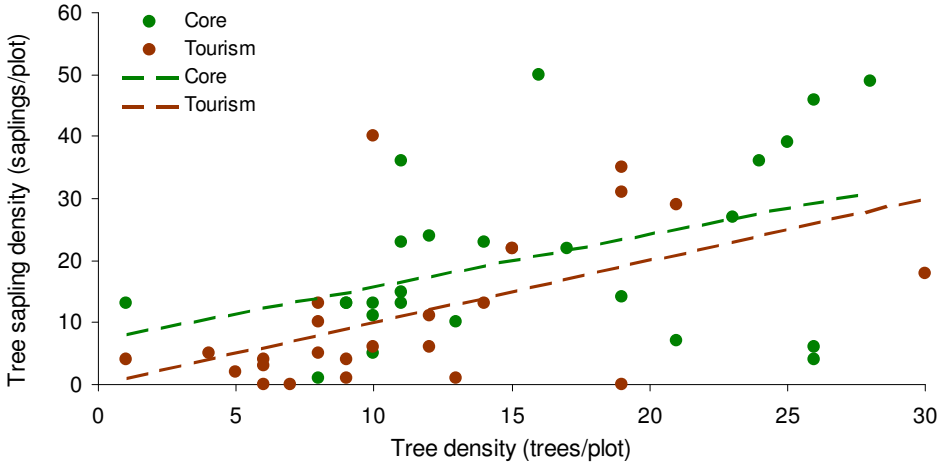

Figure 2-5. Change in tree sapling density (saplings per plot) along an increasing gradient of tree density (trees per plot) in the core and tourism zones of Bandipur Tiger Reserve (N = 50 plots of 10 m radius)

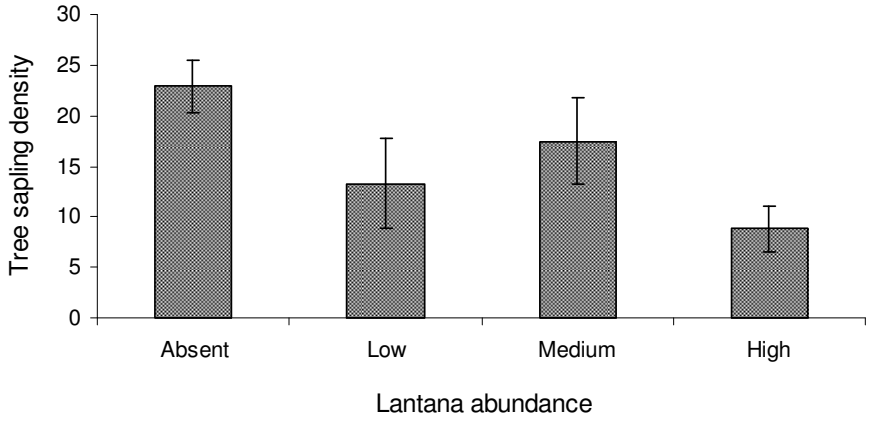

Figure 2-6. The density of tree saplings in Bandipur Tiger Reserve varied across Lantana abundance classes regardless of the presence of tourism (N = 50 plots of 5 m radius)

Similarly, mean tree sapling height also did not differ between tourism and core areas ($F_{1, 45}$ = 2.051, p = 0.159).

Tree sapling species richness — On the other hand, the species richness of tree saplings varied clearly between core and tourism zones ($F_{1, 48}$ = 27.953, p < 0.001) with core zone plots having, on average, nearly 3 times as many species of tree saplings than tourism zone plots (Figure 2-7).

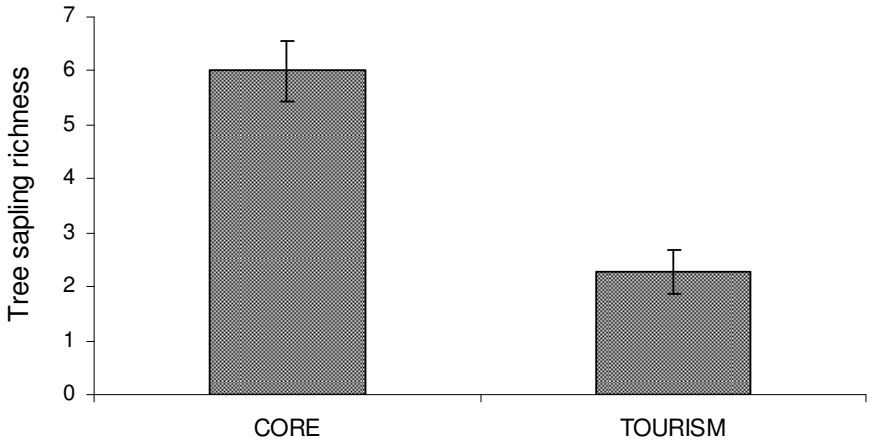

Figure 2-7. Tree sapling richness (average number of species of tree saplings per plot) compared across forest with and without tourism (N = 50 plots of 10 m radius) in Bandipur Tiger Reserve.

Tree seedling density — Whereas neither tree density nor zone (core vs. tourism) appeared to have an independent effect on tree seedling density, the interaction between the two factors explains the significant variation in tree seedling density across plots (Figure 2-8; $F_{3, 46}$ = 6.47, p = 0.011). Regardless of tree density, tourism zone plots had more plots with no tree seedlings than core zone plots. Furthermore, whereas in the tourism

zone, as tree density increased tree seedling density also increased, in the core zone the opposite trend was observed (Figure 2-8). In depth studies of factors that could drive tree seedling density in these forests will clarify the reason for this pattern.-

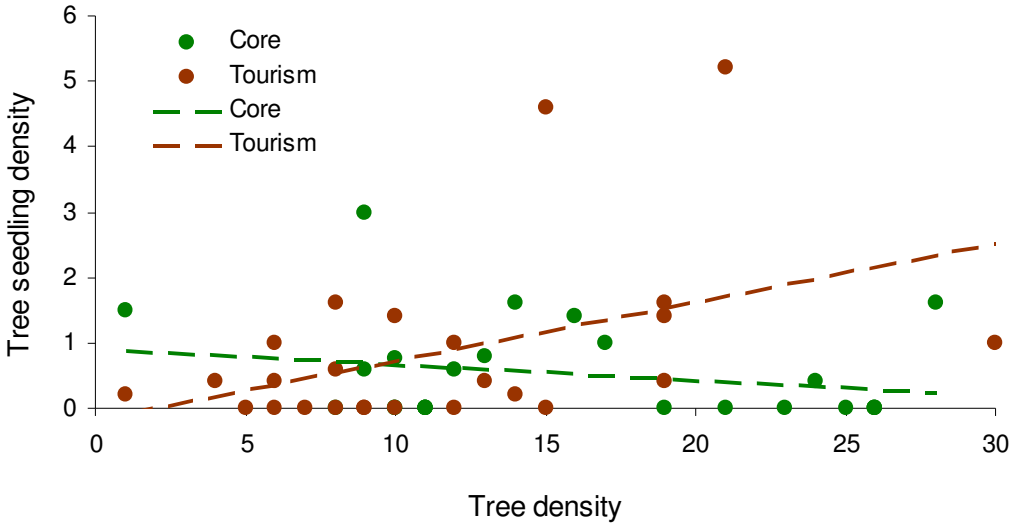

Figure 2-8. The relationship between the mean density of tree seedlings (seedlings per plot) and mean adult tree density varies between core and tourism zones in Bandipur Tiger Reserve

Tree seedling height — However, the mean height of tree seedlings in the core zone was at least 1.5 times greater than that in the tourism zone (Figure 2-9; $F_{1, 43} = 9.382$, $p = 0.004$).

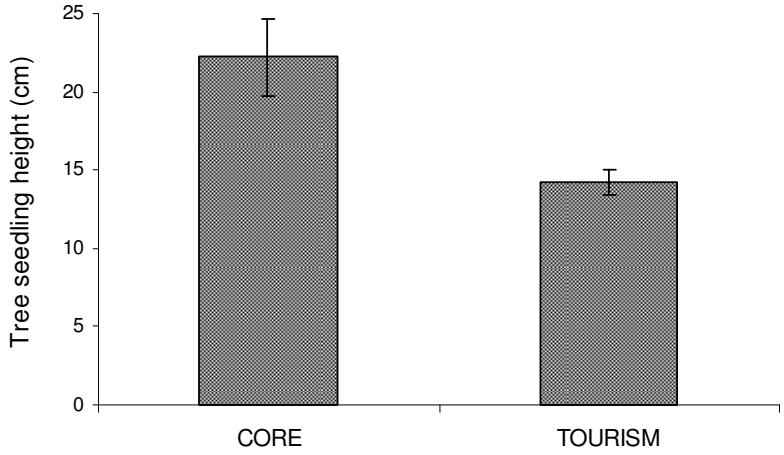

Figure 2-9. Tree seedlings appear to achieve a greater height in the core area of Bandipur Tiger Reserve (no safaris) when compared to the tourism area

There was no difference in the species richness of tree seedlings between core and tourism zone plots. There was also no difference in either the density or species richness of forbs (herbs and shrubs above 50 cm in height) between core and tourism zones.

***Eupatorium odoratum* density** — The mean density of *Eupatorium* (> 50 cm in height) did not vary across zone ($F_{1, 42} = 1.192$, $p = 0.229$) or tree density ($F_{1, 42} = 0.269$, $p = 0.607$) but was significantly different across different levels of *Lantana* biomass (Figure 2-10; $F_{1, 42} = 4.607$, $p = 0.038$). This strengthens the notion that *Eupatorium* and *Lantana* are mutually exclusive, and that *Eupatorium* colonises areas from where *Lantana* is removed.

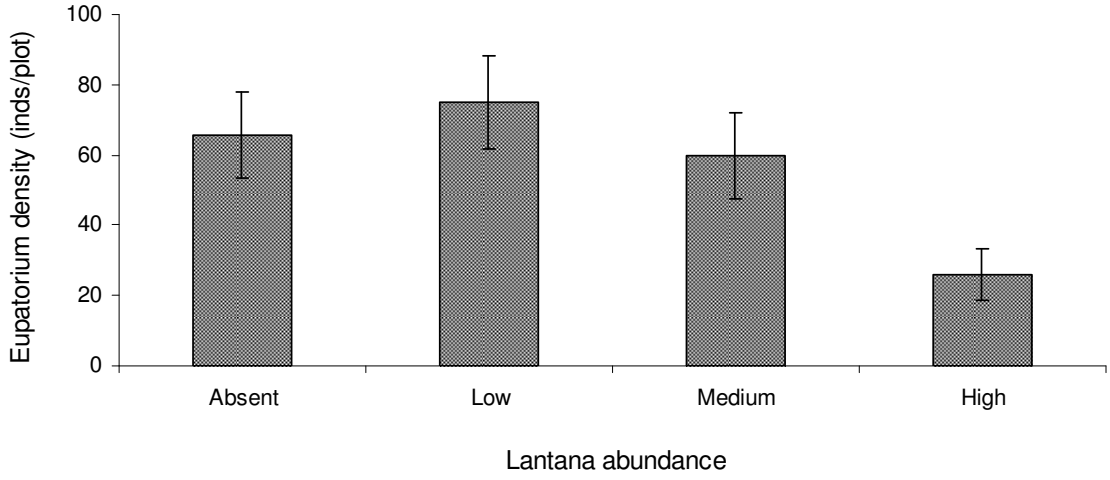

Figure 2-10. The abundance of *Eupatorium odoratum* (or *Chromalaena odorata*) in Bandipur appeared to vary across Lantana abundance classes

Neither the density nor the species richness of forb (herb and shrub) seedlings varied across zone. They were not affected by tree density or *Lantana* biomass either.

Exotic species seedling density — Whereas the density of *Eupatorium odoratum* seedlings did not vary between core zone and tourism zone plots (Figure 2-11a; $F_{1, 46} = 0.045$, $p = 0.832$), the density of *Lantana camara* seedlings (Figure 2-11b; $F_{1, 46} = 28.369$, $p < 0.001$) was significantly lower in core zone plots than in tourism zone plots. Mean seedling density of *Parthenium hysterophorus* (Figure 2-11c) could not be compared because the core zone plots had no seedlings (Figure 2-11c).

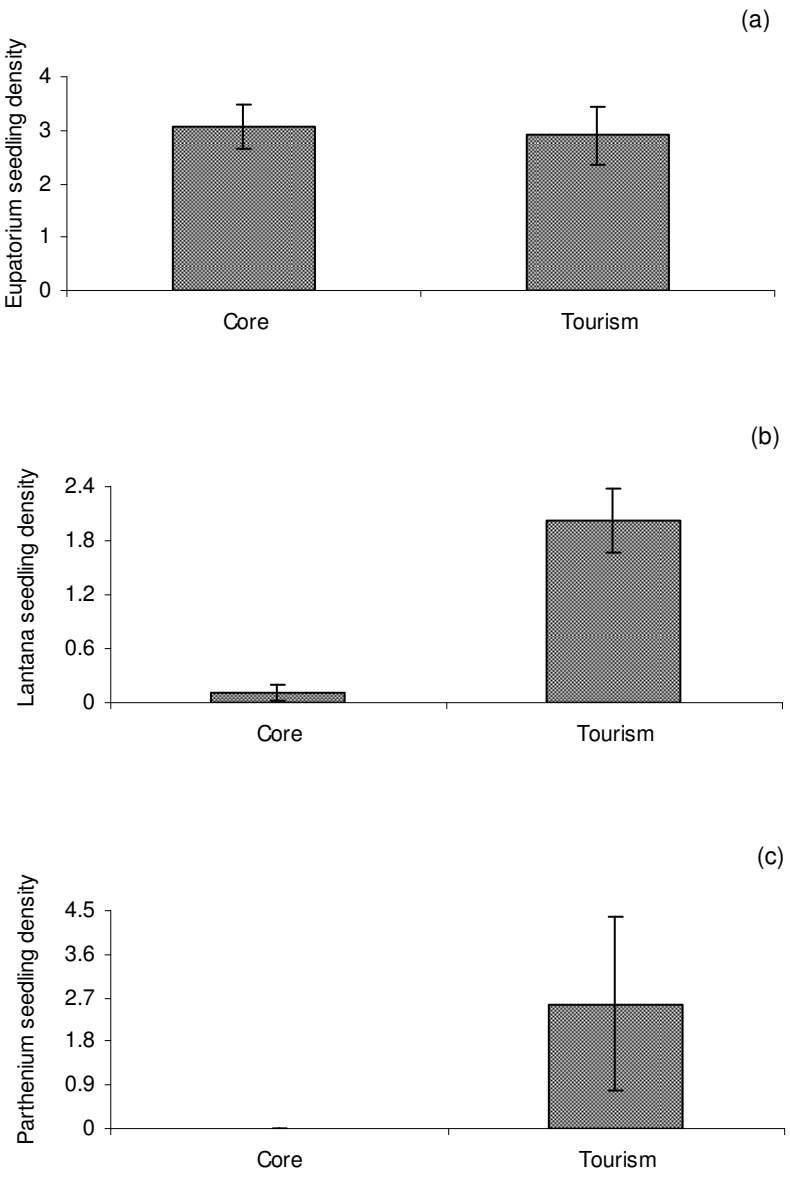

Figure 2-11. The seedling densities of three common exotic invasive plants (a) *Eupatorium odoratum*, (b) *Lantana camara*, and (c) *Parthenium hysterophorus* in the core and tourism zones of Bandipur Tiger Reserve

Grass cover — Mean area covered by grass (% cover of a 1-m^2 quadrat) varied dramatically between core and tourism zone plots (Figure 2-12a; $F_{1, 42} = 10.596$, p= 0.002). It also varied across *Lantana* abundance levels (Figure 2-12b; $F_{1, 42} = 9.423$, p= 0.003) with grass cover in areas with no *Lantana* being nearly 3.5 times that in areas with over 3 kg/m^2 of *Lantana*.

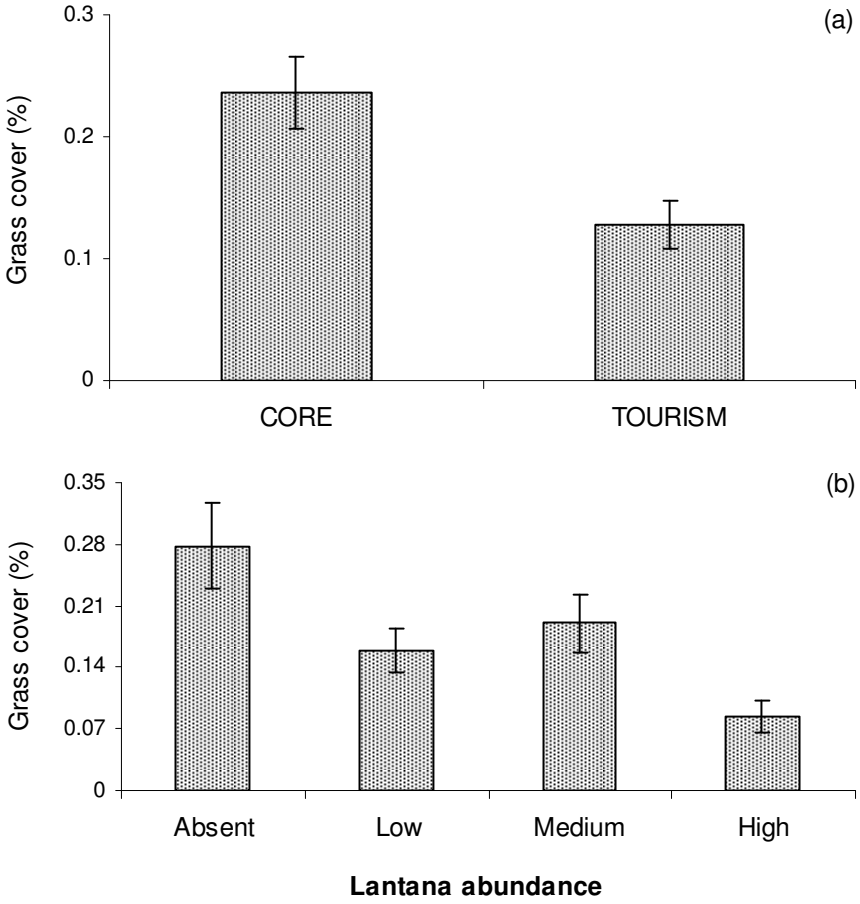

Figure 2-12. Variation in grass cover (percentage of a plot covered by grass) in response to (a) the presence of tourism, and (b) the abundance of Lantana, in Bandipur Tiger Reserve

Grass height — Mean grass height also varied clearly across zone – mean grass height in core area plots was over double that in tourism area plots (Figure 2-13; $F_{1, 42} = 15.683$, $p < 0.001$). Additionally, the interaction between *Lantana* biomass and zone played a significant role in explaining variation in grass height ($F_{1, 42} = 4.687$, $p = 0.036$). In other words, in the tourism zone, grass height did not vary across *Lantana* abundance (Figure 2-14) but in the core zone, plots with 'Absent' (0kg/m^2), 'Low' (< 1.5 kg/m^2), and 'Medium' (1.5 to 3.0 kg/m^2) levels of *Lantana* abundance had much greater grass height than plots with 'High' (> 3.0 kg/m^2) *Lantana* abundance. This indicates that, regardless of the presence of tourism (safaris and associate habitat modification and management), grass in forest with *Lantana* in excess of 3.0 kg/m^2 does not grow as tall as grass in forest with less *Lantana*.

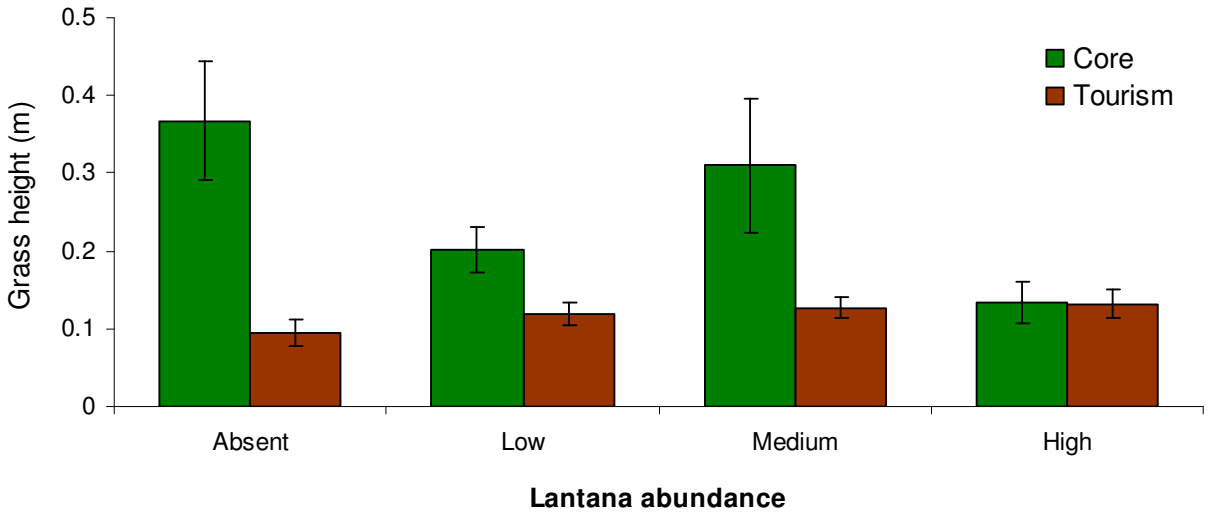

Figure 2-13. Average grass height in Bandipur Tiger Reserve varied as a response to both the presence of tourism as well as the abundance of Lantana

The species richness of grass was not affected by the presence of tourism.

UNGULATES

None of the species of ungulates sampled (including cattle) showed any measurable (within the very short time-frame of the study period) difference in relative habitat use between core and tourism zones (Figure 2-14).

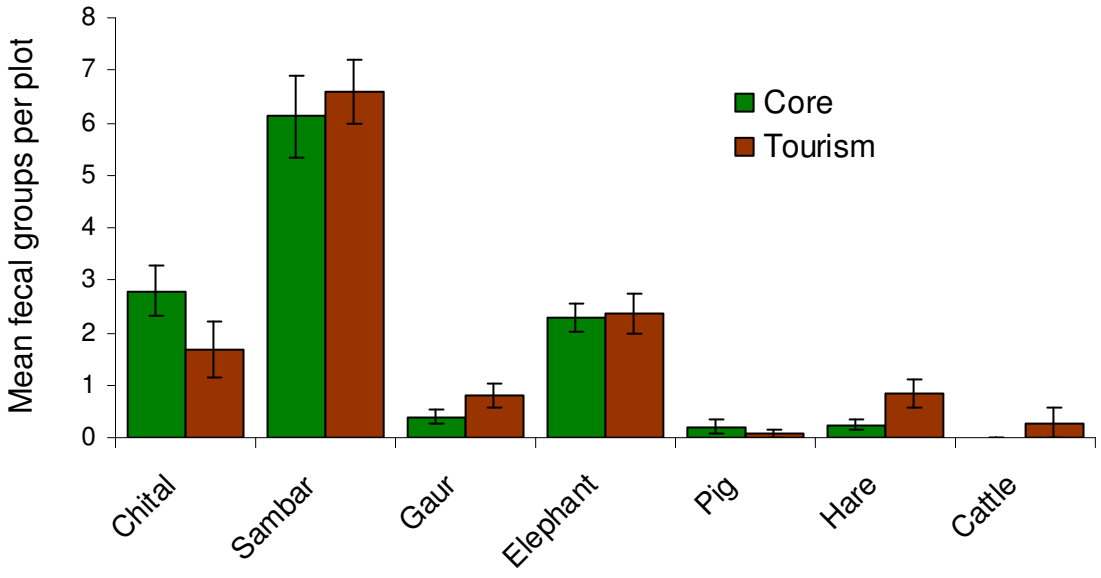

Figure 2-14. Habitat use by various ungulates (wild and domestic), as indexed by the mean number of faecal groups of each species found per plot, in the core and tourism areas of Bandipur Tiger Reserve

CARNIVORES

On the other hand, after accounting for the loss of carnivore sign on road transects to safari traffic (by doubling sign encounter rate in tourism area) whereas tiger and leopard appeared to use core zone habitats significantly more than tourism zone habitats, dhole did not show any difference (Figure 2-15, Table 2-1). This pattern may be because of the avoidance of disturbance by the large cats. Further, in-depth long-term studies area needed to understand this pattern better.

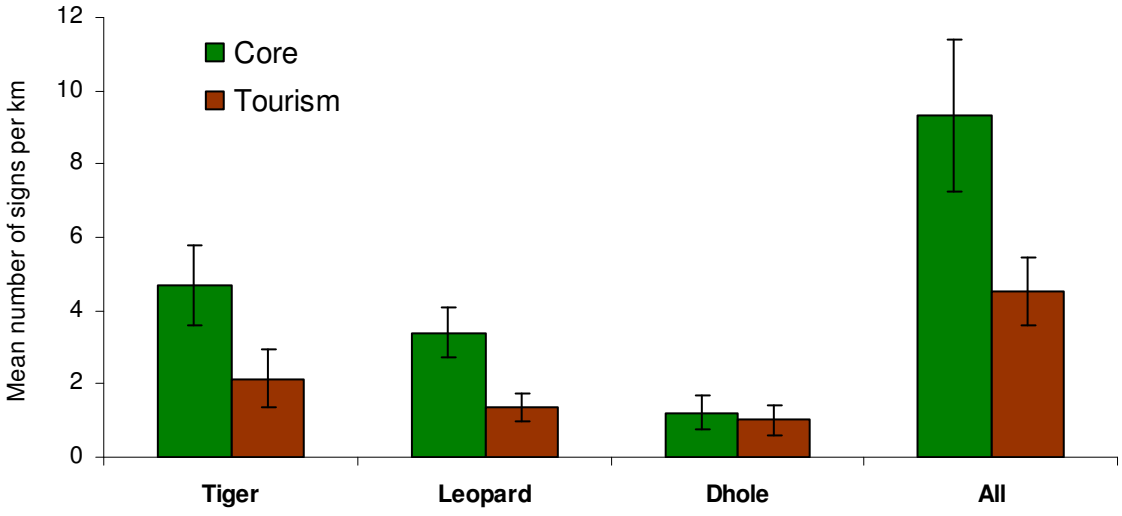

Figure 2-14. Habitat use by the 3 large carnivores, as indexed by the mean number of signs of each species encountered per kilometer of transect walked, in the core and tourism areas of Bandipur Tiger Reserve

Table 2-1. Results of a 1-way Analysis of Variance comparing carnivore sign encounter rates between core and tourism areas (data from 2 pairs of transects, each walked thrice, for a total of 54.33 km)

Species	Degrees of Freedom	F-ratio	p
Tiger	1, 10	9.7108	0.011*
Leopard	1, 10	14.265	0.004*
Dhole	1, 10	2.1806	0.171
All	1, 10	11.129	0.008*

Key findings

1. Tree density was higher in the core zone. Lower tree death (but not significantly lower) in the core zone might play a role in explaining why tree density is higher in the core zone.
2. Tree species richness was also significantly higher in the core zone.
3. Tree sapling density was higher in the core zone. However, this difference is explained by variation in tree density and *Lantana camara* biomass across the zones. In other words, tree sapling density increased with tree density and decreased with *Lantana*.
4. Tree sapling species richness was also dramatically higher in the core zone.
5. Tree seedling density appeared to respond to the interaction between zone and tree density. That is, in the tourism zone, tree seedling density increased with tree density whereas in the core zone tree seedling density decreased (less steeply) with tree density.
6. Tree seedling height was greater in the core zone than the tourism zone.
7. Density of adult *Eupatorium odoratum* individuals did not differ between zones but responded clearly to *Lantana* biomass, with much lower density in areas of 'High' *Lantana* biomass compared to 'Absent', 'Low' and 'Medium' *Lantana* biomass.
8. The density of *Eupatorium odoratum* seedlings did not vary between core and tourism zones. However that of *Lantana camara* and *Parthenium hysterophorus* did.
9. Grass cover was much higher in the core zone than the tourism zone. Mean grass cover also decreased clearly as *Lantana* abundance increased.
10. Grass height in the core zone was found to be over double that in the tourism zone. Grass height also decreased with increase in *Lantana*.
11. None of the ungulates seemed to differ in relative habitat use between tourism and core areas.
12. The carnivores, however, responded differently. Whereas tigers and leopards appeared to use the core zone much more than the tourism zone, dholes did not show any difference.
13. Lantana invasion is a major factor to consider in this area. Drivers such as habitat modification, fire mismanagement and other disturbances have been shown to be primarily responsible for widespread invasion in the area. In understanding impacts observed in the tourism zone the impacts and management of Lantana must also be considered.

Chapter 3. Dandeli-Anshi Tiger Reserve

Introduction

The Dandeli-Anshi Tiger Reserve (DATR; 815 km^2; 11°57′ N, 76°12′ E - 11°35′ N, 76°51′ E) is located in the northern part of the Uttara Kannada district. Declared a tiger reserve in 2007, DATR was formed by joining Anshi National Park (340 km^2) with Dandeli Wildlife Sanctuary (475 km^2). The western side of the Tiger Reserve (Anshi), receives heavy rainfall (3000-6000 mm) from the south-west monsoon and is covered by mostly tropical evergreen forest. Further east in Dandeli, however, away from the rain-rich slopes of the Western Ghats, the forest is deciduous – a combination of dry and moist depending on micro-climate.

For this study we selected Dandeli as our study area because we were investigating the impacts of tourism, particularly safaris and associated accommodation, on the forest and whereas Anshi has very low levels of tourism and no safari, Dandeli has safaris as well as many more tourist accommodation facilities. Hereafter, we will refer to the study area as Dandeli and all study area descriptions to follow pertain to the mixed deciduous forests of the Dandeli Wildlife Sanctuary (within DATR) and its surrounding settlements.

In Dandeli, dry and wet seasons are distinct, each lasting approximately 6 months (dry, January to June, wet, July-December). Fires are common in the early dry season between January and April. In the dry season, trees shed their leaves, and flush soon after the pre-monsoon rains.

Flora

The deciduous forests of Dandeli are dominated by the tree species *Terminalia* spp. (*tomentosa* and *paniculata*; Combretaceae), *Grewia tiliaefolia* (Tiliaeceae), *Xylia xylocarpa* (Fabaceae), *Lagerstromia lanceolata* (Lythraceae), Careya arborea (Lecythidaceae), *Dalbergia latifolia* (Fabaceae), and *Tabernaemontana heyneana* (Apocynaceae). Vast tracts of this native forest have been converted to teak (*Tectona grandis*; Verbenaceae) plantation and in several areas forest in now almost teak monoculture. In areas where previously logged or otherwise disturbed forest has been allowed to regeneration, the early successional evergreen tree *Macaranga peltata* (Euphorbiaceae) is abundant. The native understory is grassy in drier areas dominated by dry deciduous forest and shrubby in the moist deciduous forest. Dominant shrubs include *Glycosmis pentaphylla* (Rutaceae), curry leaf (*Murraya koenigii*; Rutaceae), *Holorrhaena antidysenterica* (Apocynaceae), dwarf

bamboo (*Dendrocalamus strictus*; Graminaceae), *Helicteres isora* (Malvaceae) and *Zizyphus oenoplia* (Rhamnaceae).

Fauna

The terrestrial mammals of the deciduous forests of Dandeli include 3 species of primates (bonnet macaque *Macaca radiate*, Hanuman langur *Presbytis entellus*, and slender loris *Loris tardigradus*), 5 species of ungulates (Indian gaur *Bos gaurus*, barking deer or common muntjac *Muntiacus muntjac*, chital *Axis axis*, sambar *Cervus unicolor* and wild pig *Sus scrofa*), 3 species of cats (jungle cat *Felis chaus*; tiger *Panthera tigris*, and leopard *Panthera pardus*), 2 canids (golden jackal *Canis aureus* and dhole or Asiatic wild dog *Cuon alpinus*), 2 civets (small Indian civet *Viverricula indica* and common palm civet *Paradoxurus hermaphroditus*), 2 mongooses (common *Herpestes edwardsii*, and stripe-necked *Herpestes vitticollis*), 2 squirrels (Malabar giant squirrel *Ratufa indica* and flying squirrel *Petaurista petaurista*), sloth bear (*Melursus ursinus*), elephant (*Elephas maximus*), porcupine (*Hystrix indica*), black-naped hare (*Lepus nigricollis*) and pangolin (*Manis crassicaudata*), among others.

Over species of birds have been reported from the Dandeli region including the commonly sighted Indian peafowl (*Pavo cristatus*), grey junglefowl (*Gallus sonneratii*), cattle egret (*Bubulcus ibis*), common kestrel (*Falco tinnunculus*), Oriental honey buzzard (*Pernis ptylorhynchus*) crested serpent eagle (*Spilornis cheela*), changeable hawk eagle (*Spizaetus cirrhatus*), yellow-wattled lapwing (*Vanellus malabaricus*), spotted dove (*Streptopelia chinensis*), plum-headed parakeet (*Psittacula cyanocephala*), common hawk cuckoo (*Cuculus varius*), Indian roller (*Coracias benghalensis*), white-throated kingfisher (*Halcyon smyrnensis*) and four species of hornbills - Malabar grey (*Ocyceros griseus*), Indian grey (*Ocyceros birostris*), Malabar pied (*Anthracoceros coronatus*), and great (*Buceros bicornis*).

The common reptiles are common garden lizard (*Calotes versicolor*), Indian rock python (*Python molurus*), ornate flying snake (*Chrysopelea ornata*), Indian wolf snake (*Lycodon aulicus*), vine snake (*Ahaetulla nasuta*), common krait (*Bungarus caeruleus*), spectacled cobra (*Naja naja*), Russel's viper (*Daboia russelii*), and common rat snake (*Ptyas mucosus*).

Human presence in Dandeli Wildlife Sanctuary

The deciduous forest tract of Dandeli has historically been home to several local communities of people including the indigenous pastoral Gavli people and the forest-dwelling Siddi people, descendant of slaves brought by the British from Africa. There are still several Gavli villages within the protected area with associated cultivation and

extensive livestock grazing, particularly by buffalo. Little scientific work has been done on the impacts of these settlements on the vegetation and wildlife of Dandeli.

Tourism in Dandeli

Dandeli is off the beaten path as far as wildlife tourism is concerned. The main attraction in the region is white-water rafting which brings scores of tourists from the south of India to Dandeli. Many of these tourists (percentage unknown) also take safaris. There are few wildlife tourism-based resorts in the area (compared to Bandipur) and the major eco-tourism and safari operator in the area is Jungle Lodges and Resorts (JLR). In addition to the jeep safaris offered by JLR, one local village eco-development committee (Phansoli village) also offers jeep safaris.

Methodology

Following the sampling protocol described in the introduction (page 6-7), we investigated the impacts of tourism, specifically safaris, on 3 ecological aspects – habitat (plant communities), prey (ungulates), and predator (large carnivores) of Dandeli. For vegetation sampling we had a total of 20 plot-sets (10 each in the tourism and core areas), and for carnivore habitat use we walked two pairs of transects –one pair consisting of one 5-km transect in the core zone and one 4.5-km transect in the tourism zone, and the second pair consisting of two 5-km transects – each three times for a total of 58.5 km of transect walked.

Results

VEGETATION

Trees — None of the age classes of tree species (adults, saplings or seedlings) showed differences in density and species richness between core and tourism areas (forest with and without safari; Table 1). This suggests that the duration and or frequency of safaris in Dandeli, are at the moment not impacting the tree community.

Forbs — At the present time, safari (tourism) does not appear to have a statistically significant effect (at 95% confidence) on the density of native herbs and shrubs (forbs; Table 3-1). However, at 90% confidence, the result is significant suggesting that the difference in forb density has a 10% likelihood of being due to random chance, i.e., the core area plots had higher forb density than tourism area plots (Figure 3-1). Forb species richness did not vary between tourism and core zones (Table 3-1).

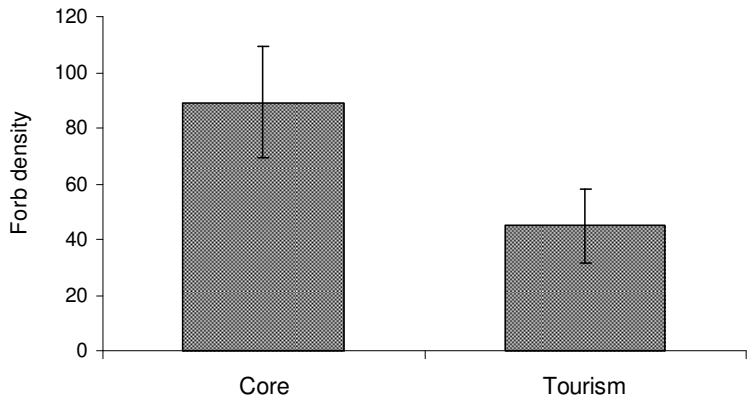

Figure 3-1. Difference in the density of forbs (native herbs and shrubs) between tourism (safari) area plots and core (non-safari) area plots.

Whereas forb seedling density also did not vary between safari and non-safari zones (Table 3-1), the species richness of forb seedlings (number of species found in each plot) was significantly higher ($F_{1, 18} = 4.5$; $p = 0.048$) in non-safari (core) zone plots than in safari (tourism) zone plots (Figure 3-2).

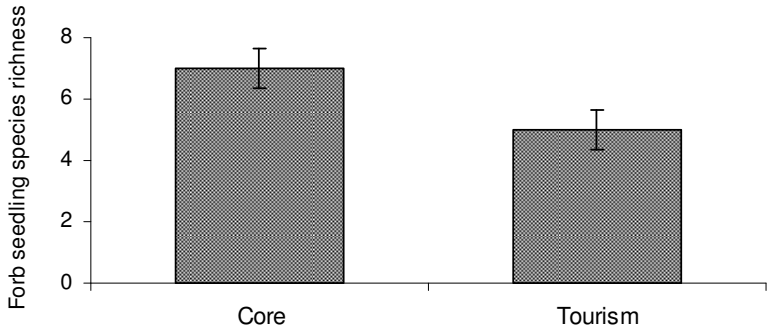

Figure 3-2. Difference in the species richness of forb seedlings between tourism (safari) area plots and core (non-safari) area plots.

Grass —The percent area covered by grass in each plot did not vary across zone (tourism vs. core; Table 3-1). However, although not statistically significant, grass cover did differ in response to the interaction between tree density and the presence of safaris - in the core area (where safaris are absent) grass cover increases as tree density increases, whereas, in the tourism area (where safaris operate) grass cover decreases with increase in tree density (Figure 3-3). It is not clear why this is so at this point.

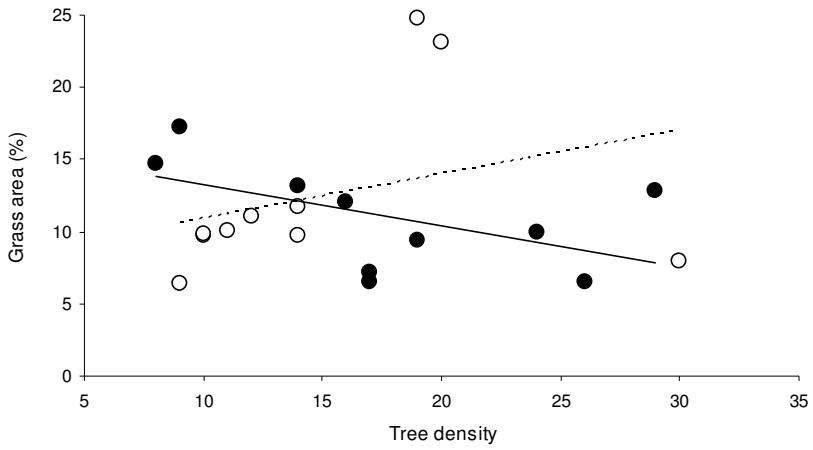

Figure 3-3. Change in the percentage of plot covered by grass (grass cover) along an increasing gradient of tree density in tourism (safari present) and core (safari absent) zones in Dandeli.

The species richness of grass also shows the same trend – positive correlation with tree density in the core zone but negative correlation in the tourism zone - except that the trend is statistically significant (Figure 3-4; $F_{1,16} = 4.552$, $p = 0.049$).

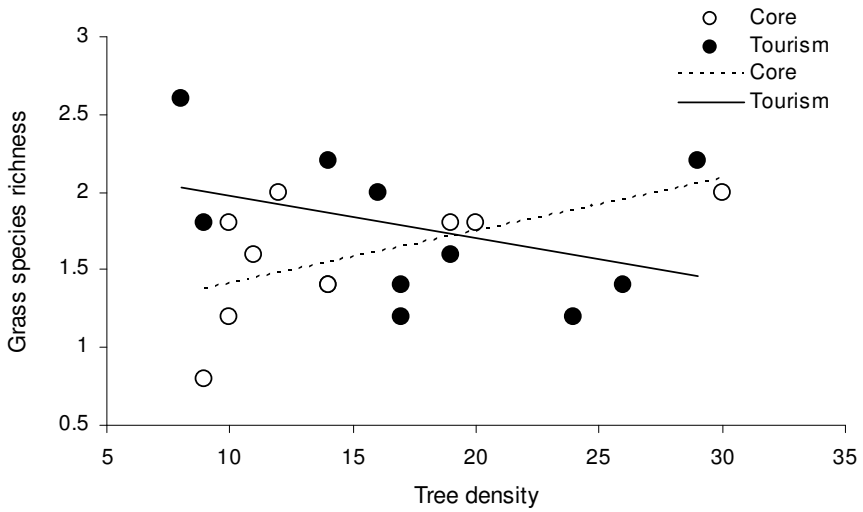

Figure 3-4. Change in the number of species of grass per plot (grass cover) along an increasing gradient of tree density in tourism (safari present) and core (safari absent) zones in Dandeli.

UNGULATES

Of all the ungulate species surveyed, only chital showed a significant difference in relative habitat use (as indexed by number of pellet groups found in a plot) between tourism and core zones ($F_{1,12} = 6.154$, $p = 0.029$) with habitat use in the core zone being almost twice as much as that in the tourism zone (Figure 3-5).

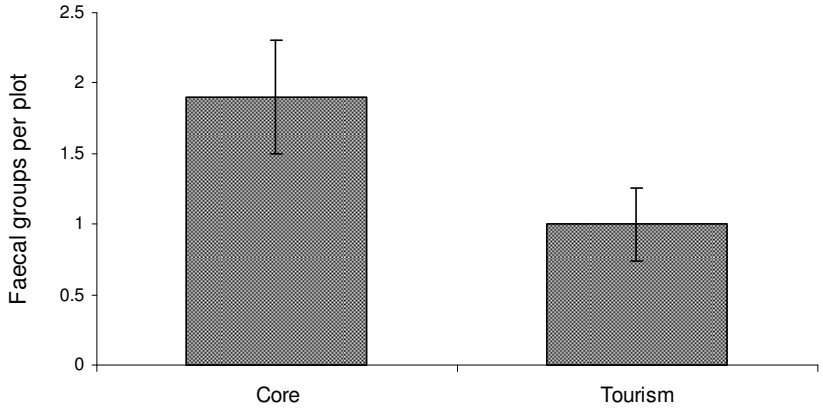

Figure 3-5. Relative habitat use by chital in core and tourism zones (n = 20 plots) in Dandeli.

Interestingly, the presence of livestock and grass cover were also found to be linked to chital relative habitat use. The interactive effect of livestock presence, grass cover (%) and tourism (presence or absence of safari) on chital habitat use was significant ($F_{1,12}$= 9.943, $p < 0.01$). This is because of two overlapping patterns:

(a) Whereas in the presence of livestock (in plots where livestock dung was found), chital habitat use did not vary significantly between core and tourism, in plots where no livestock sign was observed, chital habitat use was higher in core zone plots than in tourism zone plots (Figure 3-6).

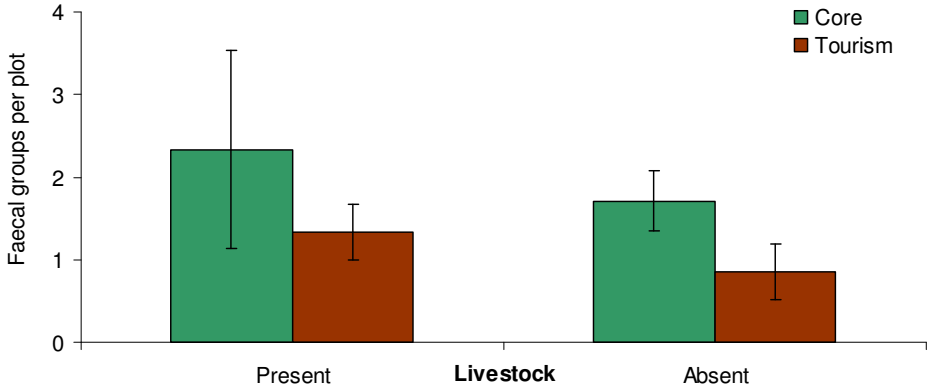

Figure 3-6. Relative habitat use by chital in plots with and without livestock across core and tourism zones (n = 20 plots) in Dandeli.

(b) Regardless of tourism, chital habitat use increased as a function of grass cover. However, overall habitat use was higher in the core zone than in the tourism zone (Figure 3-7).

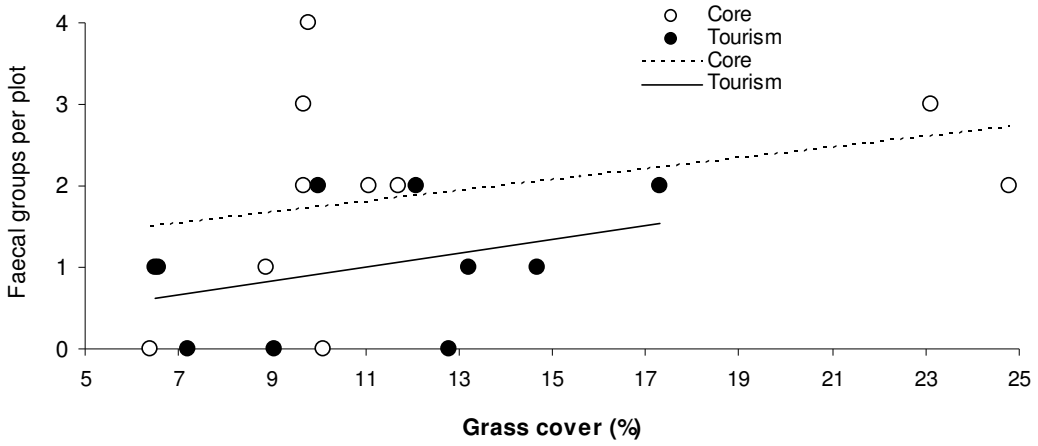

Figure 3-7. Relative habitat use by chital increased along an increasing gradient of grass cover (percentage of plot area covered by grass) across core and tourism zones (n = 20 plots) in Dandeli.

This 3-way interaction (the influence of concurrent, linked factors) on chital habitat use is difficult to explain without experimental studies that examine each of these factors independent of one another, before examining them together. The most plausible explanation at this point, in the absence of experimental data, is that both livestock and safaris somehow affect grass cover which is an important factor influencing habitat use by grazers such as chital. The other grazer in the assemblage, gaur, also shows a similar pattern but this pattern is not statistically significant (Table 3-1). On the other hand, the dominant browser, sambar, appears to be unaffected by livestock, tourism or grass cover (Table 3-1). However, when taken together, all three species of ungulates respond significantly to the presence of safaris in their habitat ($F_{1,12} = 6.366$, $p = 0.027$; Figure 3-8).

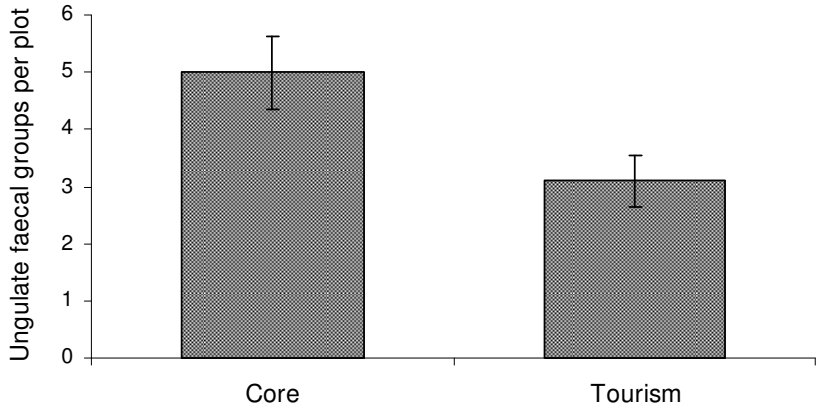

Figure 3-8. Overall ungulate (chital, sambar and gaur taken together) habitat use in Dandeli varied significantly between core and tourism zones (n = 20 plots).

Their response to livestock in their habitat is not statistically significant but deserves mention (Figure 3-9).

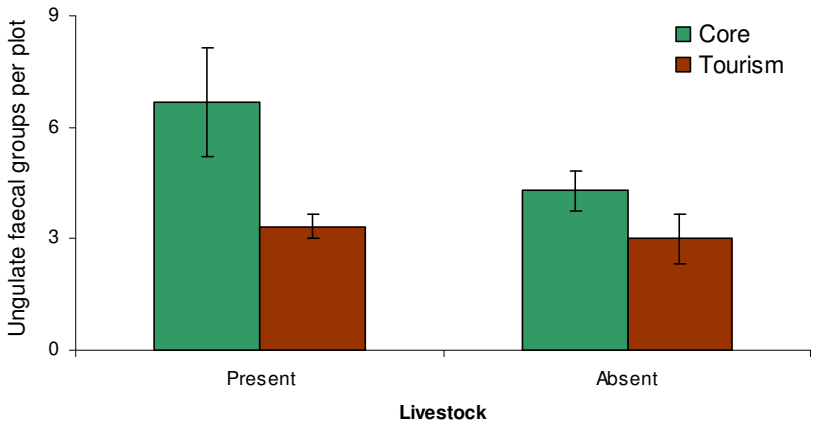

Figure 3-9. Overall ungulate (chital, sambar and gaur taken together) habitat use in Dandeli does not vary significantly between core and tourism zones in plots where livestock are absent but is significantly higher in the core zone in plots where livestock are present (based on 20 plots).

CARNIVORES

After accounting for the loss of carnivore sign on road transects to safari traffic (by doubling sign encounter rate in tourism area) only leopard showed a significant difference in habitat use (indexed as encounter rate of sign in average number of sign encountered per km of transect) between core and tourism zones ($F_{1, 10} = 9.765$; $p = 0.012$); leopard appeared to use tourism zone habitats significantly more than core zone habitats (Figure 3-10). One possible explanation, which needs to be experimentally validated, is that leopards frequent areas in and around villages in search of livestock such as goats, more than other carnivores, and the tourism zone in Dandeli has more villages than the core zone (selected for per this study).

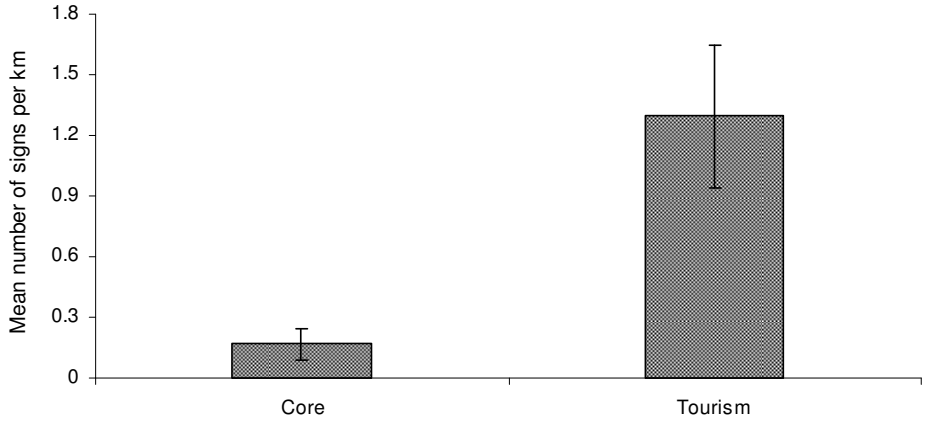

Figure 3-10. Leopard habitat use in Dandeli (as indexed by the number of leopard sign – scats, tracks and scratch marks – encountered per km of transect walked) was significantly higher in the tourism zone when compared to the core zone. Means are based on 2 transects in each zone, walked 3 times each.

Table 3-1. The effect of zone (tourism vs non-tourism), on vegetation, ungulates and carnivore habitat use in Dandeli

	Degrees of Freedom	F-ratio	P
Tree density	1, 18	1.008	0.329
Tree girth	1, 18	0.197	0.663
Tree death	1, 18	0.315	0.582
Tree species richness	1, 18	0.477	0.499
Tree sapling density	1, 18	0.862	0.366
Tree sapling height	1, 18	0.229	0.638
Tree sapling species richness	1, 18	0.729	0.404
Tree seedling density	1, 18	0.115	0.739
Tree seedling height	1, 15	0.008	0.928
Tree seedling species richness	1, 18	0.698	0.415
Forb density	1, 18	1.286	0.272
Forb species richness	1, 18	3.433	0.080
Forb seedling density	1, 18	3.888	0.064
Forb seedling species richness	1, 18	4.5	0.048
Eupatorium density	1, 18	<0.004	0.995
Grass area	1, 18	0.485	0.495
Grass height	1, 18	0.206	0.656
Grass species richness	1, 18	0.863	0.365
Chital	1, 12	6.154	0.029
Sambar	1, 12	0.908	0.359
Gaur	1, 12	1.142	0.306
Ungulates	1, 12	6.366	0.027
Tiger	1, 10	0.084	0.778
Leopard	1, 10	9.765	0.012
Dhole	1, 10	1.048	0.330
Carnivores	1, 10	1.473	0.253

Key findings

1. The tree community (adults, saplings and seedlings) did not appear to differ between areas with and without safari. It may be concluded that either at this point in time, or at this level, tourism does not impact the Dandeli tree commuity.
2. Forbs (native herbs and shrubs), on the other hand, did respond to tourism with significantly higher forb density in areas where there are no safari.
3. The density and species richness of forb seedlings was also higher in the core zone.
4. Grass cover was not significantly decreased by tourism but showed an interesting trend in response to the interaction between tourism and tree density – in the presence of tourism (safari) grass cover decreased as tree density increased, however, in the absence of tourism (core zone where there are no safaris) grass cover increased with increase in tree density. The ecological process underlying this pattern can only be determined experimentally and is outside the scope of this work.
5. Grass species richness also showed the same pattern as grass cover – positive correlation with tree density in the core zone but negative correlation in the tourism zone.
6. Chital were the only ungulate species to respond markedly to tourism - chital habitat use in the core zone was almost double that in the tourism zone. Furthermore, chital responded to a 3-way interaction between tourism, the presence of livestock and grass cover in their habitats. In both core and tourism zones, chital habitat use was higher in plots were livestock was present, and increased with increase in grass cover.
7. Overall ungulate habitat use (chital, sambar and gaur taken together) was significantly higher in the core zone that in the tourism zone.
8. Leopard habitat use appeared to be much higher in the tourism zone than in the core, pattern which may be a result of leopards stalking livestock in and around villages which are more numerous in the tourism zone.
9. When compared to Bandipur Tiger Reserve, where safari traffic is much greater, Dandeli does not appear to be heavily impacted by tourism. Other factors such as the presence of villages and livestock within the forest may have greater impacts on the vegetation and wildlife of this protected area.

Chapter 4. Bhadra Tiger Reserve

Introduction

The Bhadra Tiger Reserve (hereafter Bhadra ; 13°22'N- 13°47'N and 75°29'S- 75°47'S) is spread over an area of 492km^2 in Chikmagalur district. First notified as a Wildlife Sanctuary in 1972, Bhadra was declared a Tiger Reserve in 1998. The Bababudan hills bisect the Reserve into two approximate halves – the Muthodi and Lakkavalli regions. The terrain is generally gently undulating and can be hilly in areas; altitude ranges from 670 to 760 masl. The Reserve is drained by several ravines as well as perennial streams, such as Somavahini Halla, Tadve Halla, Wate Halla and Hippla Halla. The south-western and western boundaries of the reserve are defined by the Bhadra river. When this river was dammed in 1967, a large reservoir that inundated several square kilometres of forest was created. The reservoir lies, in greater part, within the boundary of the Reserve and its backwaters provide grazing lawns for herbivores and habitat for water birds during much of the year.

Mean annual temperatures range between 10 and 32°C. The hottest months are April and May, in the late dry season, and the months of December and January, following the retreating south-west monsoon are the coolest. Bhadra receive most of its rain from the south-west monsoon between June and September. The Jagara valley receives higher rainfall than Lakavalli area, which is in the rain-shadow of the Bababudans. We selected Lakkavalli range to conduct this study because the bulk of the tourism in Bhadra occurs here. Safaris and other types of tourism in the south-western Muthodi region is intermittent, not nearly as extensive or intensive as that in Lakkavalli, and it based more on coffee plantation resorts and visits to the hills than ecotourism within the Reserve.

Flora

Lakkavalli's location within the rain shadow limits the precipitation it receives. The canopy is predominated by several dry deciduous forest species such as *Anogeissus latifolia, Tectona grandis* (Verbenaceae), *Dalbergia latifolia* (Fabaceae), *D. paniculata*, *Terminalia tomentosa* (Combretaceae), *T.paniculata*, *T.bellerica*, *Pterocarpus marsupium* (Fabaceae), *Lagerstroemia microcarpa* (or *lanceoata*; Lythraceae), *Grewia tilaefolia* (Tiliaceae), *Randia dumetorum* (Rubiaceae), *Emblica officinalis* (Euphorbiaceae), and *Gmelina arborea* (Fabaceae), as well as large bamboo (*Bambusa arundinacea*; Poaceae). The dominant native understory is mainly short bamboo (*Dendrocalamus strictus*). Evergreens such as *Syzygium cumini* (Myrtaceae), *Mangifera indica* (Anacardiaceae) and *B. arundinacea* are found in riparian zones as well. Invasive species such as *Lantana camara*, *Eupatorium odoratum*, and *Parthenium hysterophorus* are yet to successfully invade Bhadra as they have Bandipur.

Fauna

In addition to being home to over 200 species of birds, both resident and migrant, Bhadra has an impressive assemblage of large mammals. The ungulates found here include gaur (*Bos gaurus*), sambar (*Cervus unicolor*), chital (*Axis axis*), muntjac (*Muntiacus muntjak*), Indian chevrotain (*Tragulus meminna*) and wild pig (*Sus scrofa*). Elephants (*Elephas maximus*), which occur across the Reserve, appear to migrate to the backwaters of the Bhadra reservoir in the dry months. The primates found here are the common langur (*Presbytis entellus*) and bonnet macaque (*Macaca radiata*). The large carnivore community consists of tiger (*Panthera tigris*), leopard (*P. pardus*), dhole (*Cuon alpinus*), and striped hyena (*Hyaena hyaena*). The meso-carnivores include lesser cats (*Felis* spp.), civets (*Viverricula* and *Paradoxurus* spp.), mongooses (*Herpestes* spp) and jackal (*Canis aureus*). The sloth bear (*Melursus ursinus*) and the common monitor lizard (*Varanus benghalensis*) are also commonly seen in Bhadra.

Human presence in Bhadra Tiger Reserve

Bhadra Tiger Reserve is well-known for the 'successful' relocation of villages from within the Muthodi range. So at present, there are no human settlements within Bhadra, although the impacts of the relocated villages may expect to diminish and disappear only over time. Owing to the presence of coffee plantations within Muthodi range (in the Bababudans hills) all manner of human-related impacts occur here including forest fragmentation, pollution of water bodies from coffee pulping, and poaching. In the Lakkavalli area, human impacts stem mainly from the numerous villages along its eastern boundary. These impacts include livestock grazing , collection of fuel-wood and other minor forest produce, and poaching.

Tourism in Bhadra Tiger Reserve

Not as heavily visited as Bandipur, and not as remote as Dandeli, Bhadra attracts visitors from as far as Bangalore, Mysore and Chikmagalur. Jungle Lodges and Resorts (JLR) is the only forest-related tourist accommodation facility in the Lakkavalli area, and most of the visitors who come to Bhadra stay at JLR which offers splendid views of the vast Bhadra reservoir fringed by grassy shores and bamboo thickets, with the undulating landscape in the background. But the star attraction at JLR Lakkavalli is the safari into the forest.

Safaris run in a specifically designated tourism area centred largely along the backwaters. During the rainy months the reservoir swells and submerges the grassy banks. Backwater drives are, therefore, possible only between the months of December and May. Inside the forest, safari roads are bordered by view-lines, clearings that run along both sides of roads and increase visibility for viewing wildlife, and are 20-30 m wide. View-lines are

maintained by cutting and burning understory vegetation at least once a year. Furthermore, waterholes (both natural and manmade), check-dams, clearings and salt-licks are regularly maintained throughout the year in order to 'improve' the habitat for large wildlife (mainly ungulates, elephants and large carnivores), and attract them to the area where tourists have higher probability of spotting them. We expected that the combination of high road density, greater vehicular traffic, and the management/modification of forest increase wildlife sightings would lead to differences in vegetation, large herbivore and large carnivore communities between safari (tourism) and non-safari (core) forest.

Methodology

Following the sampling protocol described in the introduction (page 6-7), we investigated the impacts of tourism, specifically safaris, on 3 ecological aspects – habitat (plant communities), prey (ungulates), and predator (large carnivores) of Bhadra. For vegetation sampling we had a total of 26 plot-sets (13 each in the tourism and core areas), and for carnivore habitat use we walked two pairs of transects (each 5 km long) three times each for a total of 60 km of transect walked.

Results

VEGETATION

Certain strata of the forest vegetation community in Bhadra showed marked differences between core and tourism zones.

Trees — The tourism area plots had significantly more trees per plot than core area plots ($F_{1, 24} = 5.505$, $p = 0.028$; Figure 4-1). At this time, this pattern cannot be explained. A more detailed study of the factors controlling tree population dynamics in the region should shed light on the cause of this difference. Neither tree death not tree size (GBH) differed significantly between tourism and core areas (Table 4-1).

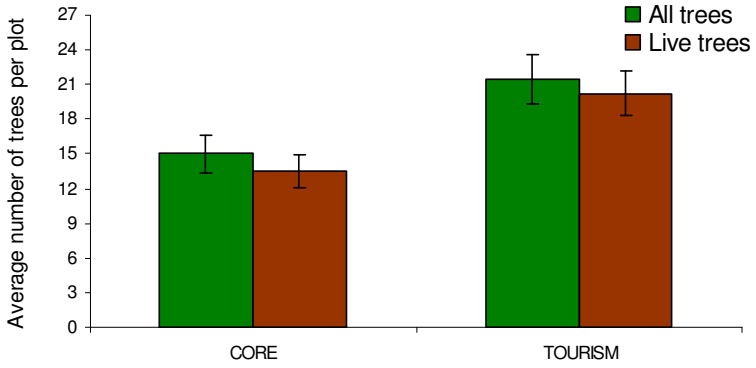

Figure 4-1. Density of live and all trees as determined from 50 circular plots of 10 m radius in Bhadra Tiger Reserve

Tree sapling and seedling communities (density, height and species richness) were similar in both zones (Table 4-1).

Forbs — Neither the density nor the species richness of adult forbs (herbs and shrubs taller than 50 cm) across zone (Table 4-1). Similarly, the density of forb seedlings was also similar in both zones (Table 4-1). However, the species richness of forb seedlings varied significantly between core and tourism zones ($F_{1, 24} = 6.3$, $p = 0.019$) with core zone plots having higher forb seedling species richness than tourism zone plots (Figure 4-2).

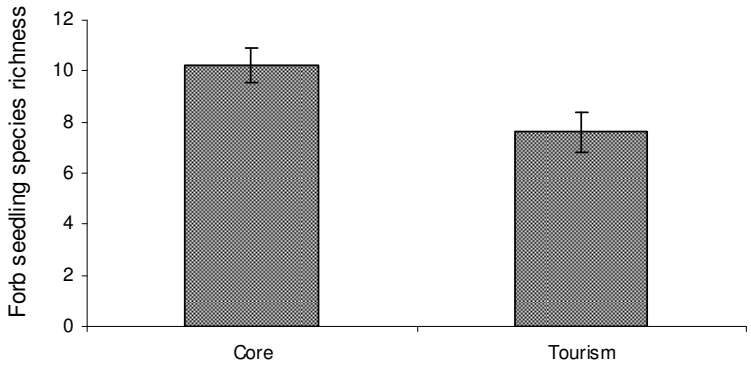

Figure 4-2. The species richness of forbs (native herbs and shrubs) in the core and tourism areas of Bhadra as calculated from data collected in 26 plots

The density of the exotic annual *Eupatorium odoratum* (both adults and seedlings) was also similar in both zones (Table 4-1).

Grass — The Analysis of Variance showed that mean area covered by grass (% cover of a 1-m^2 quadrat) was not influenced by zone (core vs tourism) but varied significantly according to tree density ($R^2 = 0.1881$, $F_{1, 22} = 5.1380$, $p = 0.034$; Figure 4-3). These data support existing knowledge that in tropical deciduous forests, rainfall-related increase in tree density (and thereby shade) drives decrease in grass cover.

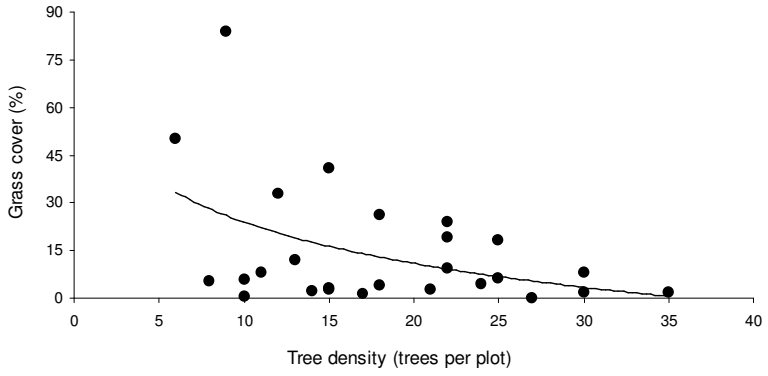

Figure 4-3. Mean percentage of plots covered by grass in Bhadra Tiger Reserve decreases exponentially as a function of mean tree density

Grass height and species richness were not influence by either zone or any other factor that was included in the study.

UNGULATES

None of the species of ungulates sampled showed any measurable (within the very short time-frame of the study period) difference in relative habitat use between core and tourism zones (Figure 4-4; Table 4-1).

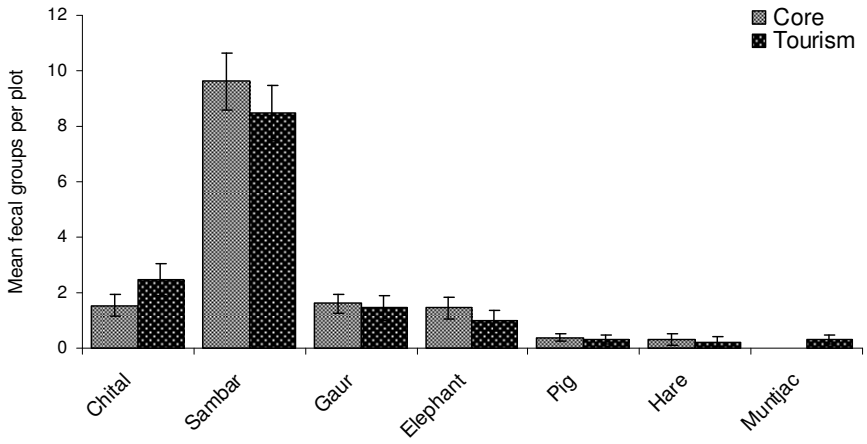

Figure 4-4. Habitat use by wild ungulates, as indexed by the mean number of faecal groups of each species found per plot, in the core and tourism areas of Bhadra Tiger Reserve

CARNIVORES

On the other hand, after accounting for the loss of carnivore sign on road transects to safari traffic (by doubling sign encounter rate in tourism area) only leopard appeared to show a difference in relative habitat use between the 2 zones (Figure 4-6; Table 4-2) – leopard use the tourism area significantly more than the core area ($F_{1, 10} = 6.202$, $p = 0.032$).

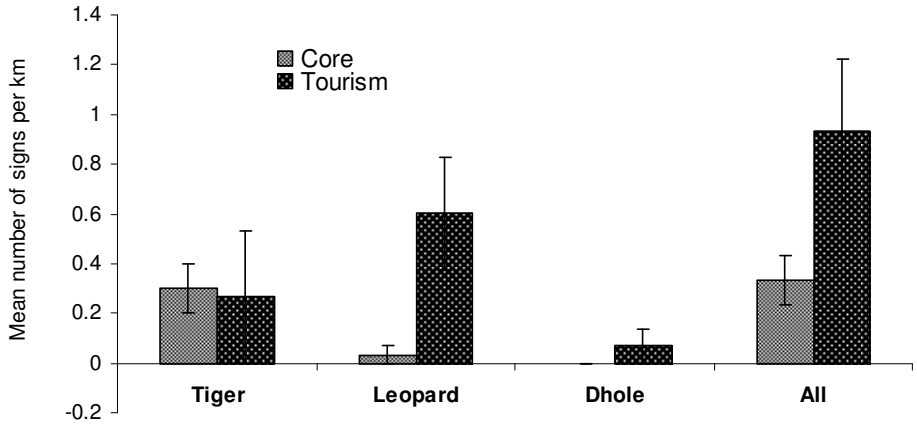

Figure 4-5. Habitat use by the 3 large carnivores, as indexed by the mean number of signs of each species encountered per kilometer of transect walked, in the core and tourism areas of Bhadra Tiger Reserve

Table 4-1. The effect of zone (tourism vs non-tourism), on vegetation, ungulates and carnivore habitat use in Dandeli

	Degrees of Freedom	F-ratio	P
Tree density	1, 24	5.506	0.028*
Tree girth	1, 24	< 0.01	0.996
Tree death	1, 24	3.572	0.071
Tree species richness	1, 24	0.446	0.510
Tree sapling density	1, 24	3.032	0.096
Tree sapling height	1, 24	0.079	0.782
Tree sapling species richness	1, 24	0.781	0.386
Tree seedling density	1, 24	1.266	0.272
Tree seedling height	1, 15	1.883	0.183
Tree seedling species richness	1, 24	2.661	0.116
Forb density	1, 24	0.301	0.589
Forb species richness	1, 24	0.259	0.616
Forb seedling density	1, 24	4.117	0.054
Forb seedling species richness	1, 24	6.3	0.019*
Eupatorium density	1, 24	1.324	0.262
Eupatorium seedling density	1, 24	2.723	0.112
Grass area	1, 24	0.013	0.911
Grass height	1, 24	0.028	0.870
Grass species richness	1, 24	0.001	0.973
Chital	1, 24	1.577	0.222
Sambar	1, 24	0.595	0.451
Gaur	1, 24	0.079	0.782
Ungulates	1, 24	0.042	0.840
Tiger	1, 10	0.014	0.909
Leopard	1, 10	6.022	0.032*
Dhole	1, 10	1.0	0.341
Carnivores	1, 10	3.932	0.076

Key findings

1. Tree density was higher in the tourism zone.
2. Forb seedling species richness was greater in the core zone
3. The percent area of forest floor covered by grass decreased significantly as a function of tree density but was not affected by zone.
4. None of the ungulates showed any response to tourism with similar relative habitat use in both zones.
5. Among the carnivores, only the leopard appeared to show a response to tourism – it used tourism zone habitats significantly more than core zone habitats, a pattern which cannot be explained given limited scope of the present dataset.

Chapter 4. Conclusion

Over the course of three months we collected data on vegetation characteristics and large mammal habitat use in three very different protected areas (PAs) in Karnataka. The three sites selected for case studies represented unique and interesting scenarios along the tourism type and intensity continuum. Therefore, they also presented different challenges for conservation and interesting perspectives on the significance and sustainability of tourism in these landscapes. Here we summarize broad conclusions and identify important avenues for future research on the effects of tourism on forests and wildlife in Karnataka.

Bandipur

The greatest ecological impacts on both vegetation as well as wildlife were seen in Bandipur. Repeated cutting of Lantana and other vegetation in viewlines, , in order to maximize wildlife sightings, may eventually lead to the transformation of these dry deciduous forests into treeless, exotic-dominated shrublands. The effect of intensively managing the forest within the tourism area has clearly resulted in forest degradation. **The clearing of Lantana needs to be carried out in a scientifically rigorous and sustainable manner**. Efforts need to also be made to restore native, forage-rich vegetation in areas from which Lantana has been cleared by uprooting. Without a better understanding of the role of fire in altering the dynamics of this ecosystem repeated burning of viewlines may cause irreversible long-term damage to these habitats.

Although the methodology employed in this short-term study is not a good measure of habitat use by large carnivores, it is not entirely unreliable. Even if what has been observed are only broad and coarse trends, the patterns reported here must not be ignored. Clearly all three species of large carnivores appear to utilize safari zones significantly less than forest areas without safaris. This suggests that perhaps a combination of habitat degradation and disturbance from vehicles drives this difference. **The number of safari vehicles entering the Reserve each morning and evening needs to be reduced and capped.** Furthermore, even though there is a zonation system in place this is not being strictly followed. **Safari vehicles must be made to stick to their routes** with not more than one vehicle per route per hour. **Tourists must be made to undergo a mandatory orientation** regarding the forest and safari do's and don't's before they are taken on safari. **Tourists who do not comply with safari rules and regulations must be penalized**. Overall, a much more **stringent tourism policy** for tourist operators, tourism zone managers and tourists themselves needs to be instituted. This should pave the way for more responsible and ecologically sustainable tourism in the region.

Dandeli

During the course of field work we noticed that the sighting frequency of large mammals, which is what the safari is geared towards, is extremely low in Dandeli, when compared to places like Bandipur and Nagarhole in Karnataka. In other words, safaris in Dandeli spend a lot of time driving around in the forest but not seeing anything. This leaves tourists frustrated, a phenomenon which can have a strong indirect negative effect on their attitude towards the forest, wildlife and biodiversity conservation. This also consumes a large quantity of fuel and causes unnecessary disturbance to wildlife with little or no payoff. Based on our field observations, we would strongly recommend that safaris be stopped in Dandeli and replaced with a variety of treks geared towards interpretation, bird-watching, forest-seeing and photography. These activities would be more suitable because they: (a) have a much lower carbon footprint, (b) cause relatively little noise, and consequently disturbance, in the forest, (c) afford tourists a more intimate experience of the jungle, (d) disseminate more ecological information to the public, and (e) provide more work for local youth.

Bhadra

The data presented here do not show any real ecological fallout from the low-medium grade safari operations in the site. This may be either because there are few or no negative impacts from current levels of tourism or because there are other factors that have influenced the reported patterns. One such factor is that Bhadra is a strongly seasonal forest with a backwater that offers not only water to wildlife in the long and harsh dry season but also grazing grounds along its shores. Therefore, habitat use by wildlife in the dry season (January to May) is likely to be more strongly influenced by proximity to the backwater than any other factor in the habitat. Therefore even if tourism did have a negative impact on habitat use this impact is very likely to be masked by the positive effect of the backwater adjacent to the tourism zone. Studies on the impacts of tourism in strongly seasonal forests, where distinct local migrations for water are common, must be long-term and conducted across seasons to elucidate any real pattern associated with tourism.

Conclusion

The impacts of tourism in landscapes wherein the tourism zone coincides with other factors, such as, in the case of Bhadra, a reservoir, and the core zone coincides with factors, such as in the case of Dandeli, proximity to villages, need to be studied in multidimensional ways – using a combination of surveys, manipulative experiments, and over long periods of time. Studies such as this limited, short-term one, can only serve as pilot studies that

indicate the presence of some interesting patterns and cannot serve to show the full effects of tourism on the forest or wildlife.

India's high biological diversity and human population densities make it one of the world's 17 mega-diversity countries (Mittermeier and Mittermeier 2005). This juxtaposition of people and biodiversity poses diverse conservation challenges that arise from commercial interests in protected areas as well as the dependence of rural livelihoods upon forest resources. In addition to these existing challenges, the increasing influx of tourists into protected areas for wildlife viewing and nature appreciation is an added pressure upon these habitats. A sound and comprehensive but context-specific ecotourism policy with stringent regulations and attractive incentives is critical to ensuring that nature appreciation and education continue without jeopardizing the forests and biodiversity of Karnataka's Protected Areas.

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