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Conservation status of forests and wildlife in the Eastern Ghats, India

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Summary

The Eastern Ghats (EGs) comprise a chain of ancient low hills in the state of Andhra Pradesh adjoining the east coast of India. These hill ranges are well known for a rich array of tropical forests with great conservation significance which support large human populations. A series of protected areas (PAs) have been established by the government along these ranges to conserve the regional biodiversity, but their effectiveness is often questionable. In order to assess the ecological status of the forests both within and outside the PAs and to assess the impacts of ongoing forestry practices a survey was conducted along the EGs. Plant species richness, and density of shrubs and trees, were estimated along disturbance gradients (core, buffer and fringe situations) using random plots of 10-m radius for trees, and 5-m radius (nested) plots for shrubs and saplings. Indirect evidence (spoor) of domestic and wild animals was recorded within the sample plots to compare habitat use by the animals.

Srivenkateshwara National Park in the Seshachalam Hills, Gundlabrahmeshwaram Sanctuary in Nallamalais and some parts of Srisailam-Nagarjunasagar Tiger Reserve, had the least degraded forests due to their PA status. However, collection of non-timber forest products, bamboo harvesting and livestock grazing continues in all areas irrespective of legal status. All bamboo areas have been heavily worked. It is recommended that bamboo working should be stopped in core areas of the PAs and reduced from nine to six months (October to March) in the buffer zones. Summer is a period of potential water shortage for wild animals and bamboo workers' camps near water courses may affect habitat use by these species.

The proposed Gudem Maripakhala Sanctuary, well known for its biogeographical value and diverse flora, is seriously threatened as a result of to extensive '*podu*' (slash and burn) cultivation. It is suggested that an integrated approach to biodiversity conservation and better agricultural practices, should be adopted in this area. Some of the primary and old growth forests should be identified, mapped and given immediate protection, until a scientifically-based management plan is developed.

Keywords: Eastern Ghats, non-timber forest products, bamboo harvest, livestock grazing, biodiversity conservation.

Introduction

Tropical forests, the most complex of all the terrestrial ecosystems and major repository of biodiversity, are undergoing rapid fragmentation and degradation all over the world (Janzen 1988; Myers 1988, 1992). Controlling the systematic erosion of biological diversity whilst meeting the ever-increasing demands of human populations is the daunting task that confronts resource managers in developing countries, including India (Gadgil 1991; Rodgers 1991). Although India has planned a biogeographically-based network of protected areas (PAs) (Rodgers & Panwar 1988) covering about 5.6% of the total land area, nearly 75% of the country's forests and wildlife are outside of PAs. The PAs also have to sustain a large human populations.

The Eastern Ghats (EGs), a chain of ancient, low hill-ranges adjoining the east coast of India, support a diverse array of tropical forests and have great conservation significance. Much of the Deccan peninsula has dry deciduous forests and secondary scrubland, but the EGs support many remnant patches of evergreen, semi-evergreen and moist deciduous forests. Two species of *Shorea* (*S. talura* Roxb. and *S. tumbaggaia* Roxb.), red sanders (*Pterocarpus santalinus* Linn. f.), Beddome's cycas (*Cycas beddomei* Dyer), and some other associations (*Terminalia – Anogeissus – Chloroxylon*; *Hardwickia – Chloroxylon*; and *Albizia amara – Memecylon*) are unique to these ranges (Nayar *et al*. 1984). Certain wild varieties of rice (*Oryza granulata* Nees & Arn., *O. sativa* Thw., and *O. malampuzhaensis* Krish. & Chand.) have been reported from these tracts, giving these landscapes special conservation value as sources of novel genetic variation for future food crop (Ellis 1987). Besides being home to several plant and animal species, the EGs constitute important catchments of a dry peninsula. Although there are 14 PAs covering nearly 15% of the land in the entire range, the natural resources of the EGs continue to be threatened as a result of increasing demands by local and temporary settlers both inside and outside the PAs.

Several authors have stressed the need for better conservation of the EGs (Ellis 1982; Subramanyam 1982, Nayar *et al*. 1984; Beehler *et al*. 1986; Rawat & Babu 1995). The flora and fauna of the region have been well documented (e.g.; Rao 1958; Subba Rao 1979; Rao & Sudhakar 1982; Suryanarayana

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& Murthy 1984; Ellis 1987). However, information on the status of forests and wildlife in the region is fragmentary and confined to some Forestry Working Plans and a few early records such as Gamble (1884), Ghate (1939), and Legris and Meher-Homji (1982). In this paper I present a fresh assessment of ecological conditions and human use patterns in and around certain PAs of the EGs within the state of Andhra Pradesh (AP). The objectives of the survey were to: (1) assess the effectiveness of the existing PAs in conservation of forests and wildlife, (2) quantify the richness and density of tree and shrub species including non-timber forest produce (NTFP), and (3) assess the impact of ongoing forestry activities on the core and buffer zones of PAs and reserved forests in order to evolve an integrated conservation strategy. It was expected that the core areas of the PAs would have better richness and density of trees and shrubs and that the conservation status of forests and wildlife would be better in the PAs, which are buffered by social forestry programmes. The survey formed a part of the AP Forestry Project for integrated PA System Development aided by the World Bank.

Methods

Survey area

The EGs extend from the northern parts of Tamilnadu, through AP to the Mahanadi river in southern Orissa (11° 30′ to 21° 0′N latitude and 77° 22′ to 85° 20′E longitude, Fig. 1) and form an important biotic province of India's largest biogeographic zone i.e., the Deccan Peninsula (Rodgers & Panwar 1988). This province is marked by a series of isolated hills, numerous gorges, waterfalls, and wide alluvial valleys. The major rivers like Mahanadi, Godavari, Krishna, and Pennar cut through these ranges and drain into the Bay of Bengal. The EGs are spread over an area of about 75 000 km^2, and attain a maximum elevation of 1750 m above mean sea level. The northern EGs are cool and moist with mean annual rainfall of *c.* 120–160 cm, compared to southern parts which receive only *c.* 60–90 cm of annual precipitation (Subramanyam 1982).

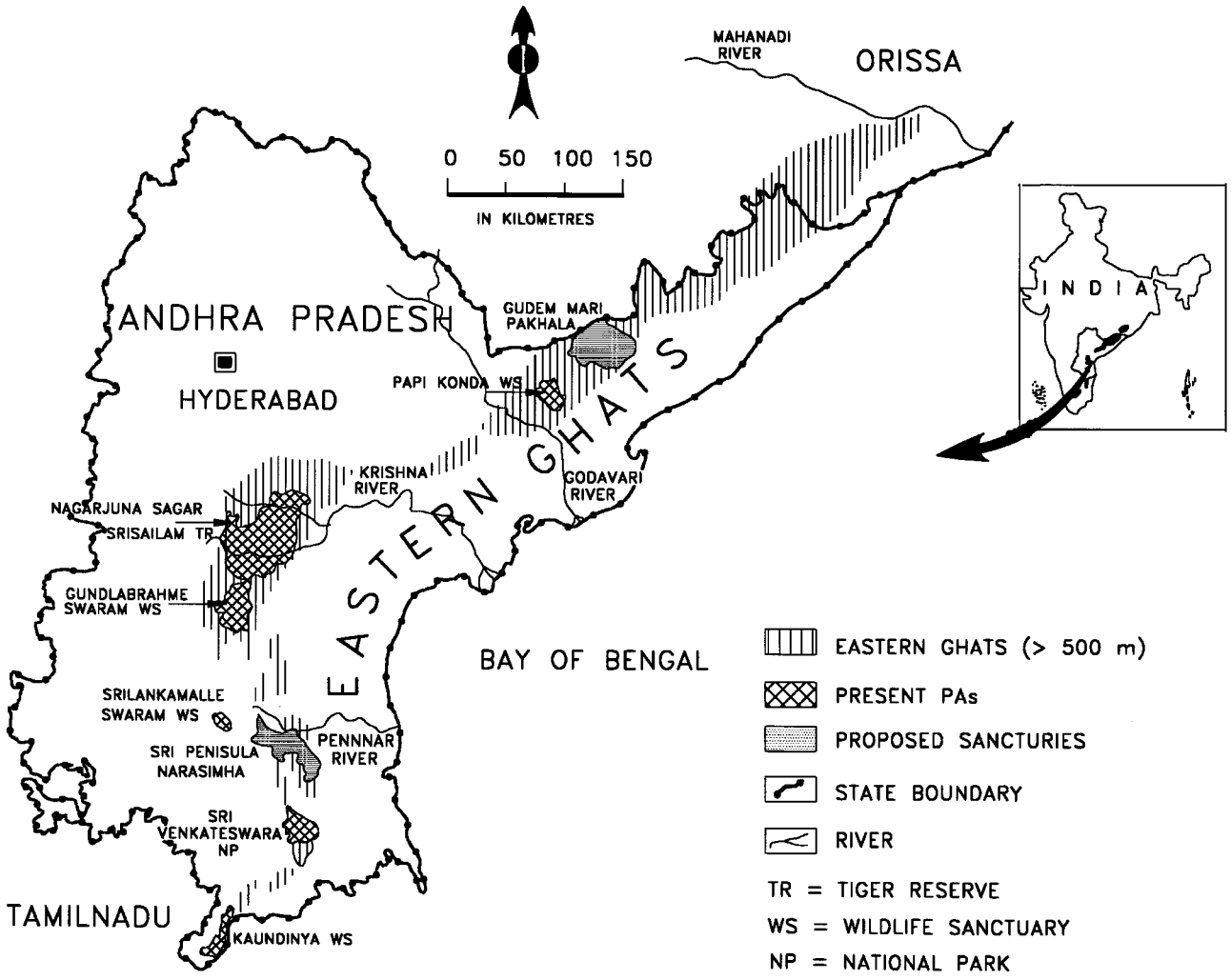

Figure 1 Map of Andhra Pradesh, India showing the location of the Eastern Ghats and adjoining protected areas.

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Survey

A rapid survey of forests and wildlife habitats was conducted during February and March 1995, in and around the following PAs of the EGs: Srivenkateshwara National Park (SVNP), Srilankamalleshwara Sanctuary (SLM), Gundlabrahmeshwaram Sanctuary (GBM), Nagarjunasagar-Srisailam Tiger Reserve (NSTR), Gudem Maripakhala (GMP) proposed sanctuary, and reserved forests along the border of Orissa state. The survey was assisted by an experienced field assessor, three or four local field staff of Andhra Pradesh Forest Department (APFD) and an expert on PA management. The data, thus collected, were precise and quite reliable. The following methodology was adopted for the survey.

(1) Areas subject to different levels of human impact were identified based on distance from human settlements and interviews with APFD officials. These areas were sampled for plant species composition and richness. The sampling design was a modified version of GRADSECT (gradient-directed transect; Austin & Heylingers 1989). Circular plots were placed randomly in zones of varying human impact (least, moderately and highly disturbed) representing core, buffer and fringe localities in relation to PAs or reserved forests. At each sampling point the following parameters were recorded: (a) Major vegetation types (tropical dry deciduous, tropical moist deciduous, tropical dry evergreen, and tropical moist evergreen forests and their stages of degradation), visual estimation of tree canopy cover (%), tree species and abundance of each all within a circular plot of 10-m radius; (b) data on abundance of bamboo clumps, girth of culms at the base, height of culms, number of cut and standing culms per clump within 10-m radius plots; and (c) abundance of woody (shrubs, tree saplings, climbers) species, % cover of shrubs, weeds and grasses, within 5-m radius nested plots. In the core area of SVNP, eight 10-m wide belt transects 1.5 to 2.5-km long were searched in order to count *Cycas beddomei* using existing trails.

(2) Direct and indirect (e.g. pellets, tracks, and burrows) evidence of wild mammals was recorded along the survey routes so as to find the relative use of the habitat by various species. In addition, special habitats or microsites along the gradsect (e.g. site with rare endemic plant, a mesic site with ephemerals, nest or den trees used by mammals and birds), and threats (e.g. extreme levels of human use of such habitats) were recorded.

(3) Several sites in and around the PAs were visited to assess the impact of current forestry practices (e.g., bamboo harvesting, collection of minor forest products, new plantations and thinning operations). Forestry Working Plans for these divisions were consulted and the officials implementing the plans were interviewed to find out the objectives and means of management. Each operation was assessed in terms of its positive or negative influence on the PA. For example, plantation of multi-purpose species for the villagers in the fringe zone in order to reduce the pressure on the PA was considered as positive, while commercial harvest of bamboo from the important wildlife areas (core) for distant users and paper mills was considered negative.

The zones of varying expected human impact were compared in terms of vegetation-structure species richness, grass and weed cover. Data on the tree and shrub densities were compared using ANOVA. Data on animal signs (spoors) were compared in terms of % frequency within various zones. General trends in human and livestock use were determined.

Results

Status of forests and wildlife

Tree densities of core, buffer and fringe areas were significantly different in the SVNP (ANOVA, $F = 9.456$, $p = 0.001$) and the SLM ($F = 9.735$, $p = 0.002$) but the differences were not significant in the GBM ($F = 3.54$, $p = 0.44$), the NSTR ($F_1 = 2.980$, $p = 0.062$), and the GMP ($F_2 = 0.221$, $p = 0.64$) (Table 1). The buffer zones tended to have slightly higher tree densities and richness compared to core zones, but these variables were far lower in the fringe zones. The core and buffer zones of most PAs showed no clear differences in the shrub density and vegetation cover, but in all cases the number of woody species was highest in the buffer zone followed by core and fringe areas (Table 1).

Evidence of wild mammals (12 species) was most often seen in the core and buffer zones of the NSTR, while there were few signs of animals in the GMP where there were only three wild mammals (Table 2). Cattle and goat pellets had consistently high frequency in all the buffer and fringe zones (Table 2).

Other observations on specific areas are given below.

Srivenkateshwara National Park

The plateau of the SVNP represents an interesting mosaic of woodland and small evergreen mesic groves. Woodland vegetation consists of several fire-resistant species such as *Terminalia pallida* Brand., *T. alata* Heyne ex Roth, *Diospyros melanoxylon* Roxb., *Pterocarpus santalinus, Buchanania acuminata* Turcz., *Madhuca indica* Gmel., and *Phoenix acaulis* Ham. Evergreen patches were rich in species of *Citrus, Mimusops, Ficus* and *Mangifera* which add to the diversity and conservation values of this Park. Several ferns, orchids, grasses and herbs, many of them endemic, (e.g. *Pimpinella tirupattensis* Bal. & Sub.) were recorded from the plateau. Chamala Valley, lying in the fringe areas of the SVNP, had high vegetation cover and more evidence of wildlife, probably as a result of the increased availability of water. In a linear stretch of about 100m 60 woody species were counted (Rawat & Babu 1995).

The core, buffer and fringe areas of the SVNP showed clear differences in the tree density and species richness attributable mainly to topographic variation. *Syzygium alternifolium* Wt., *Anogeissus latifolia* Wall., *Syzygium cumini*

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Table 1 A comparison of vegetation variables in survey areas in the EGs (details in the text): TD = tree density (ha^{-1}), SD = shrub density (per 100 m^2), n = sample size, TCC/SC = average tree canopy cover/shrub cover (%), GC/WC = % cover of grasses and weeds respectively. *F* values based on ANOVA: ^{NS}= non-significant, * = $p < 0.05$, ** = $p < 0.01$; *** = $p < 0.001$.

Survey Area	*Core*	*Buffer*	*Fringe*	*F value*
SVNP				
n	15	13	11	
TD ± SE	472.26 ± 54.0	531.10 ± 60.60	257.42 ± 75.32	9.46***
Number of tree spp.	36	42	26	
SD ± SE	44.91 ± 12.67	61.53 ± 15.06	86.57 ± 62.60	13.86***
Number of shrub spp.	51	64	37	
TCC/SC	50/35	40/30	30/50	
GC/WC	30/1	40/10	10/30	
SLM				
n	7	6	7	
TD ± SE	463.62 ± 49.12	662.86 ± 114.9	231.81 ± 28.44	9.74**
Number of tree spp.	17	22	7	
SD ± SE	31.43 ± 22.89	30.84 ± 30.60	24.32 ± 14.62 1.86^{NS}	
Number of shrub spp.	15	30	21	
TCC/SC	30/30	30/40	10/50	
GC/WC	20/0	25/4	10/5	
GBM				
n	6	15	8	
TD ± SE	503.77 ± 53.07	595.17 ± 101.9	246.58 ± 46.61	3.54*
Number of tree spp.	21	40	8	
SD ± SE	31.24 ± 21.57	27.21 ± 8.41	8.89 ± 6.27	2.35^{NS}
Number of shrub spp.	32	41	12	
TCC/SC	60/20	40/35	30/10	
GC/WC	8/0	10/0	5/0	
NSTR				
n	16	12	12	
TD ± SE	385.78 ± 44.70	408.32 ± 63.81	251.88 ± 48.88	2.98*
Number of tree spp.	49	41	26	
SD ± SE	32.17 ± 11.17	37.89 ± 9.28	35.79 ± 17.0	0.14^{NS}
Number of shrub spp.	50	56	47	
TCC/SC	30/30	20/25	20/15	
GC/WC	40/3	30/20	25/45	
GMP				
n	–	8	11	
TD ± SE	–	377.83 ± 65.90	483.04 ± 57.16	
Number of tree spp.	–	33	13	
SD ± SE	–	69.05 ± 32.42	62.11 ± 22.93	
Number of shrub spp.	–	69	49	
TCC/SC	–	50/30	10/25	
GC/WC	–	10/30	5/70	

(Linn.) Skeel, *Shorea talura* and *Pterocarpus santalinus* were amongst the most common trees in the core area. At the outer boundary, however, *Hardwickia binata* Roxb., *A. latifolia*, *Zizyphus xylopyrus* Willd., and teak (*Tectona grandis* Linn. f.) were dominant. Although the shrub density (per 100 m^2 ±SE) was highest in the fringe zone (86.57 ± 62.81, $p < 0.001$), it was contributed to by fewer species (37) as compared with the core zone (Table 1). The land formations and exposed rocks on higher slopes support very little tree growth, so that the dominance of open and scrub categories does not necessarily imply degradation. Along the survey routes, however, the flat areas close to human habitation were usually under heavy grazing pressure, resulting in a preponderance of thorny species. *Cycas beddomei*, an important endemic and xerophytic species of this region was uniformly, but sparsely, distributed on the plateau. Based on eight belt transects, the mean (±SE) density of this species was 82.2 ± 31.6 per ha. Of all the individuals counted (n = 1069), 18.4% were solitary. Clump (group) size varied from 1-8 individuals, but frequency of larger groups (clumps with 5–8 individuals) was low (<1%) resulting in low seed production and survival.

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Table 2 Relative use of core (C), buffer (B), and fringe (F) forests by domestic and wild mammals in various PAs of the EGs (details in the text) based on indirect evidence within the plots − = no evidence, + = <10% frequency, ++ = 11–50% frequency, +++ = >50% frequency. Sample size same as in Table 1). * Only two zones (B and F) were distinguishable in the GMP.

Species	*Zone*	*SVNP*	*SLM*	*GBM*	*NSTR*	**GMP*
Cattle	C	+	−	−	+	
	B	++	+++	+	++	+
	F	++	++	++	++	++
Domestic goat	C	−	−	−	+	
	B	+	+	++	++	+
	F	+++	+++	+++	++	++
Blackbuck (*Antilope cervicapra*)	C	−	−	−	−	
	B	−	−	−	−	−
	F	−	−	−	+	−
Blacknaped hare (*Lepus nigricollis nigricollis*)	C	+	++	−	++	
	B	++	+++	+	++	−
	F	++	+++	−	+	−
Blue bull (*Boselaphus tragocamellus*)	C	−	−	−	−	
	B	−	+	+	−	−
	F	−	−	−	−	−
Common langur (*Presbytes entellus*)	C	−	−	−	+	
	B	−	−	−	+	−
	F	−	−	−	−	−
Common leopard (*Panthera pardus*)	C	+	−	−	−	
	B	−	−	−	−	−
	F	+	−	−	−	−
Indian gazelle (*Gazella gazella*)	C	−	−	−	+	
	B	−	+	−	+	−
	F	−	+	−	+	−
Palm civet (*Paradoxurus hermaphroditus*)	C	−	−	−	−	
	B	−	−	−	+	+
	F	−	−	−	−	−
Porcupine (*Hystrix indica*)	C	+	−	−	+	
	B	−	−	−	++	−
	F	−	−	−	−	−
Sambar (*Cervus unicolor*)	C	−	+	+	+	
	B	−	+	+	+	+
	F	−	−	−	−	−
Sloth bear (*Melursus ursinus*)	C	+	−	−	+	
	B	−	−	−	+	+
	F	+	−	−	+	−
Spotted deer (*Axis axis*)	C	−	−	−	−	
	B	+	−	+	+	−
	F	−	−	+++	−	−
Tiger (*Panthera tigris*)	C	−	−	−	−	
	B	−	−	−	−	−
	F	−	−	−	−	−
Wild pig (*Sus scrofa*)	C	−	+	+	++	
	B	+	−	−	+	−
	F	+	−	−	+	−

Srilankamalleswara Sanctuary

The SLM is dominated by scrub vegetation. The core area had mostly rocky substratum with <30 % canopy cover with no significant difference in shrub densities among zones. However, the number of shrub and tree species in the fringe area was substantially less than in core and buffer zones (Table 1). Among the shrub species, *Diospyros chloroxylon* Roxb. and *Carissa carandas* Linn. were most frequent. These fruit-bearing species attracted a variety of birds (G.S Rawat, personal observations). Evidence of five mammal species were recorded within the sample plots. Of these, pellets of Blacknaped Hare (*Lepus nigricollis nigricollis*) were most frequent.

Gundlabrahmeshwaram Sanctuary

The core area of the GBM, especially along the stream banks, was dominated by evergreen plant species such as wild

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mango (*Mangifera indica* Linn.), *Bischofia javanica* Bl., *Terminalia arjuna* W. & A., *Ficus racemosa* Wall., and *Dillenia pentagyna* Roxb. Densities (per 100 $m^2 \pm$ SE) of shrub and tree sapling in core, buffer and fringe areas of GBM varied slightly ($F = 3.54$, $p < 0.05$). A large number of woody climbers added to the structural diversity of these forests (Rawat & Babu 1995). The forest floor is rich in grasses, herbs and ferns. The riverine areas in the core zone had more evidence of wild mammals (Table 2).

Nagarjunasagar-Srisailam Tiger Reserve

The NSTR shows a great deal of variation in topography and includes hills, valleys, plateaus, escarpments, caves and deep gorges, which support a variety of vegetation types (tropical dry deciduous and tropical thorn forests with several edaphic variations). Legris and Meher-Homji (1982) have reported four types of plant communities from this area, occurring in various stages of degradation (scrub woodland, discontinuous thorny thickets, scrub savannah and scattered scrub). About 120 villages (approximately 3000 people), and 100 000 cattle stay within the limits of NSTR. The density and richness of tree species declines from core to fringe areas but the patterns are not very clear in the shrubs (Table 1).

The *Hardwickia-Chloroxylon* community along the dry gorges of the river Krishna had fairly good (40%) grass cover. The north-facing, shady slopes have higher and greener grass cover for a longer duration. This community is unique to NSTR and its ecological significance is yet to be understood. We saw only pellets of Blacknaped Hare and Sambar Deer on these slopes. Some areas were being used for harvesting fodder grass by the local people.

Gudem Maripakhala Proposed Sanctuary

Several vegetation types were recorded in the GMP area. Low lying (200–800 m altitude) areas had mainly dry mixed deciduous forests, the common tree species including *Terminalia tomentosa*, *Xylia xylocarpa* (Roxb.) Taub., *Anogeissus latifolia*, *Diospyros sylvatica* Roxb., *Neonauclea purpurea* (Roxb.) Perill., *Macaranga peltata* (Roxb.) Muell.-Arg. Stream banks and deep ravines were characterized by semi-evergreen and evergreen forest patches, which were rich in trees, shrubs, climbers and ferns. Important species recorded were *Barringtonia acutangula* Gaertn., *Syzygium cuminii*, *Ficus hispida* Linn., *Melastoma malabathricum* Linn., *Homonia riparia* Lour., *Terminalia arjuna*, *Mangifera indica*, a rare gymnosperm *Gnetum ula* Brongn., a tree fern (*Cyathia spinulosa* Wall. ex Hk., and many orchids (Rawat & Babu 1995). The hill slopes and tops (>900 m altitude) appear like savannas which are locally known as *vanamas*. These areas are occupied by scattered stunted trees due to frequent fires during summer. There was very little evidence of wildlife in the GMP (Table 2), the likely reason being frequent hunting by tribal people as part of their culture (APFD Official, East Godawari, personal communication 1995).

Discussion

Effective management of forests and wildlife involves judicious use of resources so that at least some areas with high intrinsic values are kept inviolate (core), and sufficient buffer where spatial and temporal regulatory mechanisms are instituted can occur (Sawarkar & Uniyal 1995). The degraded fringe forests can be used for social forestry, commercial plantations, and soil and water conservation programmes. The challenge before APFD is to integrate all these activities in support of biodiversity conservation as directed by the Government of India, in its National Forest Policy (1988). The following sections deal with various human activities and their conservation implications in and around the PAs of the EGs.

Podu cultivation

Most of the hill slopes in the north EGs, and particularly those in the GMP area, show a mosaic of evergreen and moist deciduous forests with freshly cleared patches of *podu* (slash and burn) cultivation. According to local APFD officials the GMP area supports about 163 tribal villages, including a few recently migrated from Orissa. It has been estimated that 4 ha of forest area are destroyed to produce one ha of podu cultivation, which yields a modest 150–200 kg of millet (*Sorghum vulgare* Pers.) in a year (Prakasha Rao, APFD, personal communication 1995). We recorded several exotic weeds in areas of podu cultivation, such as *Eupatorium odoratum* Linn., *Parthenium hysterophorus* Linn., *Croton bonplandianum* Baill., *Lantana camara* Linn., *Mikania micrantha* Kunth., and *Hyptis suaveolens* Poit. The Forest Survey of India (1993), based on remote-sensing data, indicated that during 1989–1991 alone nearly 75 km^2 were lost to podu cultivation in the EGs. Podu cultivation appears to be a wasteful system of agriculture that will neither sustain the tribal people involved nor the forests of these areas (Rao 1991). The future of forests in the EGs can be secured only after this issue is resolved amicably.

Bamboo extraction

Based on a pre-investment survey of forest resources in Nallamalai catchment (NSTR, GBM and adjacent forests) in the early 1970s (Government of India 1972), the APFD estimated that nearly 24.3% of the forests in these hills contained bamboo (*Dendrocalamus strictus* Nees). Hence, all the subsequent working plans recommended proper utilization (exploitation) of this resource. However, there are no recent surveys and assessments on the regeneration and stock availability of bamboos.

The rapid survey of vegetation in NSTR revealed that the bamboo is restricted in distribution (to only some parts of the core and buffer zones). The core and buffer zones did not differ in the density of bamboo clumps (paired t-test $t_{26} = 0.039$, $p < 0.05$), but the mean diameter, height and number of culms per clump were lower in the buffer zone as a result of

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commercial exploitation (Table 3). According to the Director of the NSTR, only local inhabitants are permitted to exploit NSTR bamboo in the core zone. However, in other parts of Nallamalais, exploitation was heavy irrespective of legal status. Summer is a period of potential water shortage for wild animals and bamboo workers' camps near water courses may affect habitat use by these species. Therefore, it is recommended that bamboo working should be stopped completely in the core areas of the PAs and reduced from nine to six months (October to March) of the year in the buffer zones.

The GBM and adjacent forests of southern NSTR (Atmakur Division) had 11 bamboo coupes (block for operation). According to the Working Plan (Chand 1992) this area has a better stock of bamboo than parts of NSTR. Hence a target of 300 000 to 500 000 bamboo culms per year has been set in this division. Similarly, in the adjacent Giddalur Division (223.9 km^2), bamboo stock availability has been estimated to 101 450 culms per year, assuming uniform distribution and productivity. In the Atmakur range of the Nellore Division bamboo (*Bambusa arundinacea* Willd.) flowered during 1989 and 6724 bundles, each consisting of 15–20 poles, were extracted (Divisional Forest Officer Nellore, personal communication 1995).

In most of the PAs core and buffer zones have not been officially demarcated. This, coupled with lack of a clear-cut grazing policy for the PAs, poses serious problem for the field staff in protecting the core and sensitive areas from the livestock. Livestock grazing soon after bamboo harvesting is known to affect bamboo regeneration, as new shoots are exposed to browsing (Prasad 1981). Detailed ecological studies on these aspects and long-term monitoring of bamboo regeneration are recommended for this area.

Table 3 Status of bamboo (*Dendrocalamus strictus*) in the core and buffer zones of the NSTR. Bamboo clumps were not seen in the fringe areas.

Parameter	*Core*	*Buffer*
Density of clumps (ha^{-1})	167.12 (SD = 104.23)	164.25 (SD = 108.38)
Mean girth of culms at base (cm)	17.0	14.2
Mean height of standing culms (m)	6.0	4.5
Mean number of standing culms (per clump)	30.3 (SD = 23.44)	6.7 (SD = 4.33)
Mean number of cut culms (per clump)	5.57 (SD = 4.21)	13.51 (SD = 12.66)
n	16	12

Collection of non-timber forest products

The tribal and other local communities in the area collect various non-timber forest products (NTFPs) belonging to over 40 species of plants from the PAs as well as other forests. Most of the products are sold to a local Girijan Cooperative Society (GCC). The most frequently collected NTFPs are: seeds of *sal* (*Shorea robusta* Gaertn.), nux-vomica (*Strychnos nux-vomica* Linn.), mahua (*Madhuca longifolia* (Koenig) McBr, myrobalans (*Terminalia chebula* Retz., *T. bellirica* Roxb.), soap-nuts (*Acacia concinna* DC., *Sapindus emarginatus* Vahl.), tamarind (*Tamarindus indica* Linn.), leaves of Tendu (bidi) (*Diospyros melanoxylon* Roxb.) and adda (*Bauhinia vahlii* W. & A.), gum (*Sterculia urens* Roxb.), and roots of *Rauvolfia serpentina* Benth. Plant-based industries (e.g., plywood and paper) located in adjacent districts use these materials. It was found that most of the products are collected without assessing their availability and regeneration status. The method of gum extraction is very crude as the entire tree is cut. I suggest that NTFP collection should be rotated on a spatio-temporal basis and rarer species such as *Rauvolfia serpentina* and *Terminalia chebula* should be collected only once every four to five years.

The effect of NTFP collection on the wild animals could not be assessed during the present short survey. However, studies done elsewhere in India (e.g. Bhagat 1989) have shown that presence of NTFP collectors causes more direct impact than indirectly affecting the long-term availability of fodder, cover and water for wild animals.

Forestry and other activities

In north of the EGs many species of commercial importance were introduced by clearing primary forests during the colonial period (e.g., teak, mango, bamboos, cashew, coffee, and cardamom). Local people earn their livelihood by working in these plantations. Preliminary observations reveal that several patches of rich natural vegetation which are used by mammals, birds and other groups of animals, are still intact amidst these plantations. Hence these plantations may prove to be much less destructive to natural communities than podu cultivation in these tracts.

Of all the survey areas, the fringes of the SVNP seemed to have benefited most from the various afforestation programmes. These are: (1) the compensatory afforestation scheme of the Telugu Ganga Project, which has affected 10 371.40 ha area of southern AP as a result of the construction of a canal. Fifty-seven plant species, including 12 exotics, three bamboos, several NTFP and fodder species, have been planted in a 362 ha area along the eastern flanks of the SVNP. Many of these plantation sites are strategically located in terms of restricting cattle flow to the SVNP. (2) Teak

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and *Eucalyptus* spp. were planted by the APFD under a social forestry programme which, to a limited extent, meets the fuelwood and timber demand of local people. (3) The Tirupati temple committee has created several plantations for various purposes, such as greenery, soil and water conservation, propagation of medicinal plants, etc.

Plantations on the fringes of other PAs under the social forestry scheme have generally failed because of lack of maintenance and participation by the local people. Most of the APFD working plans have recommended development of silvi-pastures and fodder plots in the drier tracts of scrub vegetation. However, irrigation and drastic conversion of the scrub vegetation should be planned carefully. For example, fringe areas of the SLM, which are heavily browsed by the livestock, represent the typical southern tropical thorn forest (Champion & Seth 1968). This vegetation supports the only known population of the rare Jerdon's courser (*Cursorius bitorquatus*) (Rodgers & Panwar 1988). On the south-western flanks of the SLM, especially adjoining the Pennar river, an exotic shrub *Prosopis juliflora* (SW.) DC. has been propagated extensively to meet the fuelwood requirement of the local people, but the villagers complain that once this shrub occupies the grazing lands, livestock are forced to use other parts of the jungle. Plantation of exotic species and conversion of such habitats can pose serious threats to the native species.

The GMP area needs utmost attention from the APFD. The unique formations, namely the converging valleys, plateaus and ridges with diverse floral assemblages make this area one of the 'biological hot spots' in peninsular India. Some of the primary and old growth forests from this area should be identified, mapped and given immediate protection through the tribal communities until a scientifically based management plan is developed. The floral affinities of this area with the Western Ghats (hill ranges along the west coast of south India) and eastern Himalaya give an important clue to the former biogeographic linkages of the two regions (Abdulali 1949). The low-lying valleys in the western GMP adjoining the southern flanks of Bastar district (Madhya Pradesh state) had a small population of Asiatic wild water buffalo (*Bubalus bubalis* Linn.) until the early part of 1980s (Ranger, East Godavari APFD, personal communication 1995). Similarly, the Vizianagaram Division in the north EG , adjacent to the Orissa border, has a small area (*c.* 261 ha) of *sal* forest. Adjacent areas have been lost to podu cultivation, legal and illegal timber working, and livestock grazing. All the areas adjacent to settlements and podu cultivation are heavily infested by exotic weeds. A perennial river which flows through the area is a potential site for dense riverine forest. We found three or four old dung piles of Asiatic elephant (*Elephas maximus* Linn.) in the area. APFD field staff confirmed that a few herds of elephants still move along this river course back and forth between this range and the adjacent forests of Orissa. A few scattered evergreens, such as *Diospyros embryopteris* Pers., and *Mangifera indica* Linn., are the remains of a rich riverine vegetation, but most of the hill slopes look barren. The valley bottom supports extensive scrub vegetation including *bidi patta* (*tendu*) coppices. Collection of *mahwa* flowers by local people involves burning of the forest floor. Most of the Mahwa trees were surrounded by *Eupatorium odoratum* Linn., an exotic weed. Unless the local tribes are persuaded to adopt horticulture-based land-use practices, this area will soon be unable to sustain human life.

Conclusion

In India, conservation of biodiversity through a PA network alone seems neither tenable nor feasible because of growing conflicts between PAs and people. Large areas of forests lying outside the PA network support a considerable level of biodiversity, but the ever-increasing needs of the growing human population, and the resultant indiscriminate use of all natural resources, pose a big challenge. Since all the cultivable land along the east coast of AP has been occupied long ago, subsistence farmers have to resort to drier and more-degraded hilly tracts. Although the APFD has been engaging several tribal populations in the collection and bagging of *beedi* leaves, and bamboo and silvicultural operations, these efforts are not sufficient to check the degradation of forests. For the long-term conservation of forests and wildlife, and the survival of local human populations there seems no better option than actively to manage the degrading forests outside of the PAs, with the involvement of the local populations, so as to gradually reduce the dependence of local people on existing and proposed sanctuaries. In theory, exploitation of NTFPs from PAs should not produce a negative impact, but crude methods of exploitation, and the lack of appropriate rotation, lead to degradation. Sites of relict vegetation, sacred groves and patches of dry evergreen forest are frequent in the NSTR. Special care is needed to retain such areas through education and extension programmes.

At present, the SVNP and parts of the GBM are the least threatened PAs in the EGs. In the SLM, small patches of red sanders (*Pterocarpus santalinus*) and riverine forest are of high conservation value. At the same time, the much-neglected scrub vegetation, which is the only known habitat for the highly endangered Jerdon's courser, needs the special attention of ecologists and PA managers.

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