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Assessment of Resource Use Impact on Vegetation in Dry and Moist Tropical Forests in Satpura Conservation Area, India

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ABSTRACT

The impact of anthropogenic activities on vegetation structure was studied in dry and moist deciduous forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. Forests in both protected areas were classified into disturbed and undisturbed areas in terms of grazing, lopping, cutting etc. Vegetation in both protected areas was quantified by laying transects. 4 radial transects in 3 villages of Bori Wildlife Sanctuary were established in 4 directions and tree species composition was quantified in 10 m radius circular plots. Seedlings and ground cover were assessed in 5 random quadrats of 50x50 cm each within 10 m circular plots. The vegetation in Melghat Tiger Reserve was analysed around villages where socio-economic surveys were carried out. Tree species were quantified in 10 m circular plot established at 200 m intervals along line transects. Seedlings and ground cover were assessed in 5 random quadrats of 50x50 cm plots. Disturbance factors were quantified in both protected areas using ordinal scale of 0 to 3 scale. Data were analysed to calculate IVI, species richness, diversity, evenness and mean disturbance scores in each category of forests. *Tectona grandis* was most dominant species in three areas with *Terminalia tomentosa* being next most important species in both DF1 and DF2 (19.53 and 30.26 respectively) and *Ougenia oogeinensis* (25.25) in the undisturbed forest (UF). The overall densities of trees in the different forests did not show significant difference. Tree species diversity was higher for the undisturbed forest. The density of plants in recruitment and shrub (GBH <30 cm) class was high in disturbed forests. While grazing pressure was highest in Melghat, cutting and lopping pressures were highest in disturbed forests of Bori Wildlife Sanctuary.

Key Words: Bori Wildlife Sanctuary, Melghat Tiger Reserve, Tree density, Disturbance scores, Grazing

INTRODUCTION

In India, the tropical forests account for more than 80% of the forest cover (Singh and Singh 1988). More than 50% of these forests are moist and dry deciduous type. The moist deciduous forests have been preferred for human settlements as they contain valuable timber species like teak and have sustained permanent agriculture and forest plantations for a long time. Prolonged periods of drought pose some limitations on the rate of plant growth in the dry deciduous forest. Moreover, these forests are prone to frequent man-made fires. These fires are usually set off by the agro-pastoralists as they promote a new flush of grass. Also, the NTFP collectors light these fires to clear the forest floor, for easy collection of some categories of NTFP. Both types of fires are set off during the dry periods and therefore, have severe negative impact on the forest by destroying the under-storey of shrub cover besides burning herbs and grasses during the period when there already is a shortage of resources for the wild animals. Depending on adaptations, repeated fires affect regeneration of plants and may bring about a change in communities over time.

These tropical forests have been degraded due to immense biotic pressure from rapidly growing human and livestock populations. This has resulted in large-scale conversion of these ecosystems to savannah and open grasslands (Singh and Singh 1988). The forests of MTR and BWLS which belong to the 'Central Indian dry deciduous' and 'South Indian moist deciduous' forest types respectively (Champion and Seth 1968), are no

exception. These forests are under increasing anthropogenic pressures from people and livestock residing both inside as well as in the adjacent areas. The cutting / lopping of trees, proliferation of weeds (selective grazing leads to increase in proportion of unpalatable species over palatable species), reduction in ground cover have an adverse impact on the vegetation and wild animals of these forests.

Biotic pressures were quantified in the disturbed forests of Melghat (DF1) and Bori (DF2) and the undisturbed forest (UF) of Gugamal National Park and Tourism Zone of MTR. The latter was chosen as undisturbed forest because it was free from grazing, cutting and lopping pressures. This paper presents the findings on Impact of anthropogenic activities of local communities on the vegetation structure of both protected areas.

STUDY AREA

MTR is situated in the Satpura range of hills within the 'Central Highlands' province of the Deccan Biogeographic Zone of Peninsular India (Rodgers and Panwar 1988). Melghat Tiger Reserve (1597 km²) in the southern Satpuras, is located in Dharni and Chikhalda Tahsils of Amravati district of Maharashtra (21° 15′ N to 21° 45′ N latitude and 76° 57′ E to 77° 30′ E longitude) about 50 km from Parathwada. The Tiger Reserve comprises the Gugamal National Park (362.80 km²) and Melghat Wildlife Sanctuary, including the multiple-use area (1315.65 km). It is bounded on three sides by the forests of the East, West and South Melghat Divisions and by the Tapti river to the north and Betul district of Madhya Pradesh in the north and northeast.

In 1973, an area of 1572 km² of the Melghat forests were declared as a Tiger Reserve, which included the Dhakna-Kolkaz Wildlife Sanctuary (381.5 km²) established during 1969. Later 308.24 km² of the core area of tiger reserve and 53.60 km² of buffer were given the status of Melghat Wildlife Sanctuary in 1985. In 1987, Gugamal National Park was carved out of the Melghat Wildlife Sanctuary. It comprises the Gugamal National Park, Melghat Wildlife Sanctuary and the Multiple Use Area (MUA). MTR currently includes 1262 km² of the Melghat Sanctuary, 350 km² of Wan, Ambabarwa and Narnala sanctuaries and 362.80 km² of Gugamal National Park. In 1973 the first management plan for the Melghat Tiger Reserve was written for a period of 5 years (1973-74 to 1978-79). However, thereafter, no regular long-term management plan was written until 1987-88, when the plan was written for a period of 10 years (1988-1998).

MTR consists of a succession of hills and valleys, marked by abrupt variations in altitude, aspect and gradient. The southern part of the reserve is more rugged compared to the rest of the region. The area is drained by a number of streams in addition to 5 major rivers *viz*., Khandu, Khapra, Sipna, Garga and Dolar, which form the tributaries of Tapti river. The drainage is towards north and northwest of the reserve. The area of the reserve gradually descends towards the northwest about 950 m above MSL in the east and to about 381 m above MSL in the west, near the Tapti river.

The forests of Melghat, which are dominated by teak, typically represent the Central Indian dry deciduous forest. While teak is the dominant species (over 50%), depending upon altitude, gradient and other physiographic features, its associates may differ (Dhore and Joshi 1988). While the most common teak associates in almost all localities are *Lagerstroemia parviflora, Lannea coromandelica, Emblica officinalis, Terminalia tomentosa, Anogeussus latifolia* and *Ougenia oojeinensis*; at lower elevations its associates are *Boswellia serrata, Wrightia tinctora, Acacia chundra, Cassia fistula, Miliusa tomentosa, Bauhinia racemosa* and *Butea monosperma*; and at higher elevations and in moist localities its associates are, *Mitragyna parviflora, Adina cordifolia, Schleichera oleosa, Albissia procera, Casearea elliptica*. The "Flora of Melghat Tiger Reserve" (Dhore and Joshi 1988) documented 650 naturalised plant species, out of which 90 are tree species, 66 shrubs, 316 herbs, 56 climbers, 23 sedges and 99 grass species. In addition to these there are 72 cultivated species.

The forests of Central Indian highlands have been historically renowned for tiger, gaur and sambar, the latter two reaching their best form in this part of the country (Forsyth 1889). MTR is rich in wild fauna, major species being the tiger (*Panthera tigris*), leopard (*Panthera pardus*), wild dog (*Cuon alpinus*), hyena (*Hyaena hyaena*), jackal (*Canis aureus*), sloth bear (*Melursus ursinus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*), spotted deer (*Axis axis*), chausingha (*Tetracerus quadricornis*), nilgai (*Boselaphus tragocamelus*), wild boar (*Sus scrofa*). In addition to this, there are more than 250 bird species, 21 species of reptiles, 24 species of fishes and 4 amphibians. Regular tiger population estimation and block and water hole counts for the prey species are

carried out annually in Melghat Tiger Reserve for monitoring densities of wild animals.

Melghat region is mostly inhabited by tribes (80%), who with the establishment of British administration in the region in the 19th century, were encouraged to give up shifting cultivation and settle down. The remaining 20% population is non-tribal, i.e., scheduled castes and other backward classes. Most of them belong to agro-pastoralist communities (15%). The remaining 5% belong to scheduled castes and other backward classes. There are 61 revenue villages within the Melghat Tiger Reserve, with a human population of more than 25,000 and more that 26,000 livestock heads, while another 20 villages located outside the reserve are within a distance of 5-10 km of the boundary. In addition to the people living in and around the Tiger Reserve, over 3000 migratory cattle from Gujarat and Madhya Pradesh pass through it annually. Most of the people living in and around Melghat Tiger Reserve are dependent on it for subsistence; as a source of income from forestry works, which are continuing in adjoining reserved forest and collection of NTFP and commercial head-loading of fuelwood. In addition to all this, there are the agro-pastoralists, who have gained uncontrolled access to the forests for grazing their large herds of cattle. Their economy, which revolves around dairy-farming and dairy products, is heavily dependent on the forests. It is likely that these people would irreversibly damage the eco-system, as pastoralists do elsewhere in the country.

METHODOLOGY

Dependence of local people on the forests for fuelwood, grazing of livestock, fodder, grass collection, small timber etc., has an impact on the forest in terms of tree cutting / felling, lopping, reduced ground cover, soil erosion and compaction, proliferation of weeds, etc. Cutting of fuelwood and grazing by livestock removes biomass from the ecosystem and eventually alters species composition, effects which are not compatible with the objectives of a national park (or even a protected area) to maintain ecosystems in their natural state. Data were collected and analysed to assess the impact of resource exploitation, on the forests of MTR and BWLS.

Data Collection

Resource-use and its impact on the forest was assessed for which both primary and secondary information was collected. While the primary data regarding the impact of resource-use were collected through sampling in both MTR and BWLS, secondary information was collected from the Research Wing of Project Tiger Melghat. For quantifying resource-use and availability of resources in Bori, 4 radial transects were established in the forest around 3 of the sampled villages. Each of these transects were first marked on the topo-sheets in the 4 compass directions. Data on tree layer was collected in circular plots of 10 m radius at every 500 m on these transects. Seedlings and ground cover were measured in 5 random quadrats of 50 × 50 cm each, within the circular plots. During the sampling process in Bori it was found that radial transects were not suitable in an undulating or rugged terrain. Moreover, it was difficult to isolate the pressure of different villages in a situation where villages were scattered across the protected area and the livestock was free ranging. To overcome these limitations, this method was modified for sampling in Melghat. Sampling in MTR was carried out in the forest around the villages covered under the socio-economic survey, as well as in Gugamal National Park and Tourism Zone of MTR. This was done by laying plots in disturbed forest (DF1) along the village trails and on random transects in the UF. Data on tree layer were collected in circular plots (of 10 m radius each) at every 200 m interval on these trails. Number of seedlings and ground cover were measured in 4 random quadrates of 50 × 50 cm within the circular plots. Sample size in both Bori and Melghat were calculated by plotting cumulative frequency of tree species on Y-axis against the area sampled on X-axis, using Species-Area curve (Greig-Smith 1983, and Keel et al. 1993). Sampling was done in 5.36 ha in the DF and 1.97 ha in the UF.

Data were collected on tree species, girth at breast height (GBH) at 1.37 m from the ground, height class, percentage of cutting / lopping, weed abundance, grazing signs, number of seedlings and percentage of ground cover. All plants in 10 m radius plots with a GBH >30 cm were considered as trees. All plants with GBH <30 cm and a height of 2.5 m and above, were considered as recruitment class. Plants with GBH <30 cm and less than 2.5 m in height were considered as saplings / seedlings.

Sample Selection

The forest areas in both MTR and BWLS were sampled to assess biotic pressures and their impact. The forest around the sample villages, in both Melghat and Bori, as

well as, the forest in National Park and Tourism Zone of MTR were selected for sampling.

Sampling was carried out in the vicinity of the villages, so as to assess the availability and use of resources by the people. The forest around the villages was therefore considered as disturbed forest (DF: DF1 was in MTR and DF2 was in BWLS). Gugamal NP and Tourism Zone within the Melghat Tiger Reserve constituted the control as they were free of biotic pressures and they were considered as undisturbed forest (UF) for the purpose of the study.

Data Analysis

For the purpose of analysis the data on resource-use and its impact on the available resources were pooled area-wise (DF1 and DF2) for all villages. The data for National Park and Tourism Zone (UF) were pooled together. The data collected on tree species in the circular plots were used to calculate 1) Species richness; 2) Species diversity index; 3) Evenness; and 4) Importance Value Index (IVI). The calculations for the above were done as follows:

1) Species richness: This is the total number of species (of trees) found in any area (Magurran 1988). It provided an extremely useful measure of species richness related to DF1, DF2 and UF. Also the number of common species across the three areas were counted.

2) Species diversity Index: Species diversity is seen as an indicator of the well being of ecological systems (Magurran 1988). It is the number of individuals of each species present. Shannon-Wiener index was used for calculating the diversity of tree species present in both the disturbed (DF1 and DF2) and undisturbed forests (UF).

The equation for the Shannon-Wiener diversity index (H') is as follows:

$$H' = - \sum pi \ln pi$$

where pi may be defined as the proportion of individuals (ni) found in the ith species out of total individuals (N) of all species. The value of the Shannon diversity index (H') is usually found to fall between 1.5 and 3.5 and rarely exceeds 4.5 (Magurran 1988).

3) Evenness: This may be defined as equitable or even distribution of all individuals of the available species present in an area.

$$E = H' / \ln S$$

where, E is the measure of evenness, and S is the total number of species. The value of E lies between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant (Magurran, 1988).

4) Importance Value Index (IVI): It is the sum of the relative values of frequency, density and dominance of a species. It was calculated to characterise the vegetation in different forests and reveal its dominance (Keel *et al*. 1993). The importance value indices (IVI) of all tree species (GBH >30 cm) for the disturbed (DF1 and DF2) and undisturbed (UF) forests were calculated.

The relative values were calculated as follows:

Relative frequency (Rfreq) = (no. of plots in which a species occurs/ total no. of occurrences of all species) × 100.

Relative density (Rden) = (no. of individuals of a species/ total no. of individuals of all species) × 100.

Relative dominance (Rdom) = (basal area of a species/ total basal area of all species) × 100.

where, Basal area = πr^2 (r is the radius of a tree).

Thus, Importance Value Index (IVI) = Rfreq + Rden + Rdom.

The data was also analysed to obtain percentage distribution of stems in different girth classes (GBH) and quantify densities of trees, recruitment class and seedlings / saplings in the three areas.

For assessing the impact on the forest in terms of cutting and lopping pressure, grazing intensity and weed proliferation, visual scores were assigned to each plot using the following scale: no pressure = 0, <25% area affected = 1, 25-50% area affected = 2, >50% area affected = 3. The mean scores for each area for each pressure category (i.e., cutting/ lopping, grazing intensity / weeds) were calculated to obtain the approximate area affected. Ground cover scores obtained from the quadrat (50 × 50 cm) sampling were also pooled for each area and the mean scores calculated were as follows: no ground cover = 0, <25% ground cover = 1, 25-50% ground cover = 2, >50% ground cover = 3. Non-parametric tests were used to compare the impact of resource-use between disturbed (DF1 and DF2) and undisturbed (UF) forests.

Limitations

Quantification of impact of resource-use and estimation of growth trends was not possible due to non-availability of data for BWLS. Even though the data were available

for MTR, there was a possibility of error in estimating growth trends since the data had been collected by different field personnel. As far as the data on the impact of resource-use is concerned, a comparison between Bori and Gugamal NP may not be very appropriate as the forest in BWLS was more moist than Melghat and Gugamal although the dominant species in both areas were same. Since there were no control plots in the case of Bori WLS, as even Satpura NP, which was supposedly out of bounds for the local people and cattle, was freely used by both.

RESULTS

The forests of Melghat Tiger Reserve (DF1), Gugamal National Park and Tourism Zone in MTR (UF) and Bori Wildlife Sanctuary (DF2) were dominated by teak (*Tectona grandis*) trees, along with its various tree species associates. While most of the trees were leafless starting from late winter (MTR) to early summer (BWLS), there were riverine areas or riparian forests which were green throughout the year. The IVI of ten most dominant tree species are given in Table 1. *Tectona grandis* was found to be the most dominant species in all the three areas. The next most important species in both DF1 and DF2 was *Terminalia tomentosa* (19.53 and 30.26 respectively), while *Ougenia oogeinensis* (25.25) was the second most important species in the undisturbed forest (UF).

Table 2 shows the distribution of trees (GBH >30 cm) in different girth classes. The overall densities of trees in the different forests did not show significant difference (K-W One-way ANOVA: $\chi^2 = 0.8023$, p= 0.6695). However, the density of 60 cm and above girth class was higher for the undisturbed forest (UF) as compared to both disturbed forests (Figure 1). Tree species diversity was higher for the undisturbed forest, showing a more even distribution of individuals compared to the disturbed forests (Table 3). The comparison between the disturbed and undisturbed forests showed that 32 of the tree species were common between the different forests.

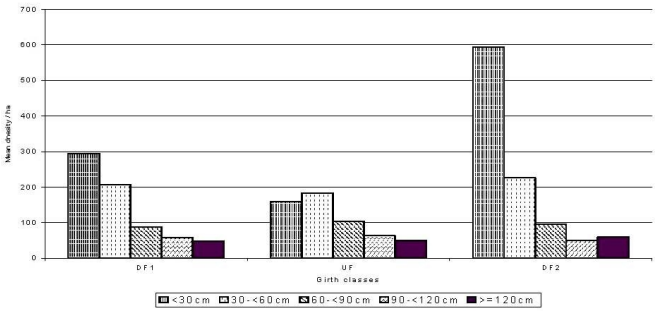

Figure 1. Density of trees in different girth classes in disturbed and undisturbed forests of Melghat Tiger Reserve (MTR) and Bori Wildlife Sanctuary (BWLS). DF1=Disturbed forest of MTR, UF=Undisturbed forest of Gugamal National Park & Tourism zone in MTR, DF2=Disturbed forest of BWLS.

Table 1. Ten most dominant tree species and their respective Importance values (IVI) in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. DF1=Disturbed forest of Melghat Tiger Reserve, UF=Undisturbed forest of Gugamal National Park and Tourism Zone in Melghat Tiger Reserve, and DF2=Disturbed forest of Bori Wildlife Sanctuary.

DF1		UF		DF2	
Species	IVI	Species	IVI	Species	IVI
Tectona grandis	146.41	*Tectona grandis*	120.28	*Tectona grandis*	83.30
Terminalia tomentosa	19.53	*Ougeinia oojeinensis*	25.25	*Terminalia tomentosa*	30.26
Lagestromea parviflora	14.81	*Lagestromea parviflora*	15.72	*Diospyros melanoxylon*	21.57
Ougeinia oojeinensis	12.10	*Zizyphus xylopyra*	13.94	*Madhuca indica*	16.74
Anogeissus latifloia	9.59	Garuga pinnata	13.46	*Zizyphus xylopyra*	15.03
Boswelia serrata	8.91	*Terminalia tomentosa*	12.00	*Chloroxylon swietiniodes*	13.42
Butea monosperma	8.25	*Grewia tiliaefolia*	10.80	*Lannea coromandelica*	12.55
Emblica officinalis	6.55	*Adina cordifolia*	7.34	*Butea monosperma*	8.46
Adina cordifolia	6.32	*Anogeissus latifolia*	7.23	*Saccopetalum tomentosum*	8.15
Mitragyna parviflora	5.11	*Kydia calycina*	6.18	*Emblica officinalis*	8.06

Table 2. Mean density (Number ha^{-1} ±S.E.) of trees in different girth classes in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. GBH= Girth at breast height, DF1, UF and DF2 as in Table 1.

GBH classes	DF1	UF	DF2
30 to <60 cm	207.33 (14.97)	183.71 (19.48)	225.81 (31.45)
60 to <90 cm	86.94 (6.31)	104.08 (9.26)	95.48 (11.25)
90 to <120 cm	58.22 (3.93)	63.17 (4.50)	50.69 (8.08)
³120 cm	46.97 (4.04)	48.98 (3.99)	59.14 (9.84)
Total	320.87 (14.85)	334.03 (20.97)	318.89 (34.71)

Table 3. Tree species richness (S), species diversity (H´) and evenness (E) in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. DF1, DF2 and UF as in Table 1

Forest	Species richness	Species diversity	Evenness
DF1	62	2.0373	0.493
UF	48	2.4246	0.626
DF2	47	0.2939	0.076

Table 4 gives the recruitment and shrub (GBH <30 cm) densities. Disturbed forests of both Melghat (DF1) and Bori (DF2) had higher density in this class, which was statistically significant ($p< 0.01$), as compared to the undisturbed forest (Figure 1). There were significant differences in densities between all the areas ($p<0.001$, Mann-Whitney U-test, Table 5). Table 5 shows the densities of seedlings across the disturbed and undisturbed forests. Highest densities were found in undisturbed forest (14502 individuals ha^{-1}). Although seedling densities showed significant difference ($p< 0.01$) across the three areas, Mann-Whitney U-test showed that the difference in seedling densities between undisturbed (UF) and Bori (DF2) forests was not significant (Table 5). The forests of both MTR and BWLS were under anthropogenic pressures in terms of cutting and lopping of trees for fuelwood, timber and fodder. They were also used by the local people for grazing domestic livestock and collecting NTFPs. On the basis of information collected from the local people, six major tree species used by the people for fuelwood, fodder, timber and NTFP were identified i.e., *Anogeissus latifolia* (dhaora), *Ougeinia oojeinensis* (tiwas), *Termi-nalia tomentosa* (saj), *Buchanania lanzna* (chironji), *Madhuca indica* (mahua) and *Diospyros melanoxylon* (tendu). Table 6 shows the percentage representation of these species in regeneration, recruitment (<30 cm GBH) and tree classes (>30 cm GBH) out of the total number of stems found in

Table 4. Recruitment and shrub class densities (number/ha±S.E.) and pair wise comparison using Mann-Whitney U-test in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. DF1=Disturbed forest of Melghat, Tiger Reserve, UF=Undisturbed forest of Gugamal National Park and Tourism Zone of Melghat Tiger reserve, and DF2=Disturbed forest of Bori Wildlife sanctuary.

DF1	UF	DF2	Chi Square	DF1 and UF Z value (P)	DF1 and DF2 Z value (P)	UF and DF2 Z value (P)
293.5 ±22.7	159.5 ±14.6	594.2 ±95.7	33.1 (P<0.01)	-3.4 (<.0005)	-3.8 (<.0001)	-5.4 (<.0001)

Table 5. Seedling densities (number/ha±S.E.) and pair wise comparison using Mann-Whitney U-test in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. DF1=Disturbed forest of Melghat, Tiger Reserve, UF=Undisturbed forest of Gugamal National Park and Tourism Zone of Melghat Tiger reserve, and DF2=Disturbed forest of Bori Wildlife sanctuary.

DF1	UF	DF2	Chi Square	DF1 and UF Z value (P)	DF1 and DF2 Z value (P)	UF and DF2 Z value (P)
3909 ±537	14501.9 ±1498	10947.3 ±1576.3	60.8 (P<0.01)	-7.7 (<.001)	-4.7 (<.001)	-1.8 (<.06)

Table 6. percentage of total number of stems of major tree species used by the people in seedling (S), recruitment (R) and tree (T) class in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. DF1=Disturbed forest of Melghat Tiger Reserve, UF=Undisturbed forest of Gugamal National Park and Tourism Zone in Melghat Tiger Reserve, DF2=Disturbed forest of Bori Wildlife Sanctuary.

Species	DF1			UF			DF2		
	S	R	T	S	R	T	S	R	T
A. latifolia	9.8	4.4	2.4	14.3	2.2	1.7	2.1	11.4	1.4
O. oojenensis	15.6	3.0	4.4	29.7	9.4	9.5	2.1	00.9	0.6
T. tomentosa	3.9	2.3	4.5	09.9	1.8	2.5	14.6	04.4	9.2
B. lanzan	—	0.9	0.5	—	—	1.2	—	0.9	1.2
M. indica	—	0.2	0.7	—	0.4	1.2	—	1.0	46
D. melanoxylon	5.8	2.9	0.9	2.2	1.1	0.3	6.3	16.0	9.8

Table 7. Density (number ha^{-1} ±S.E.) of cut and lopped trees in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary. GBH=Girth at breast height,

Girth classes	DF1	UF	DF2
<30 cm	133.81 (±11.90)	32.25	161.29 (±26.16)
30 to <60 cm	68.41 (±4.61)	53.76 (±21.50)	91.61 (±12.17)
60 to <90 cm	50.86 (±4.79)	-	57.60 (±6.03)
90 to <120 cm	32.25	-	46.08 (±6.52)
³120 cm	32.25	-	50.18 (±7.81)
Total	183.77 (±13.58)	64.52 (±32.26)	251.42 (±32.77)

Table 8. Disturbance scores in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary.

	DF1	UF	DF2	Chi Square
Grazing & Weeds	2.14 ±0.06	0.19 ±0.06	2.03 ±0.13	131.647 ($p<0.01$)
Cutting & Lopping	1.56 ±0.07	0.03 ±0.02	2.32 ±0.12	139.722 ($p<0.01$)

that class. While *Anogeissus latifolia* (dhaora) and *Ougeinia oojeinensis* (tiwas) were primarily used for fuelwood, *Terminalia tomentosa* (saj) was used both for fuelwood, small timber as well as fodder. The last three species, i.e., *Buchanania lanzan* (chironji), *Madhuca indica* (mahua) and *Diospyros melanoxylon* (tendu) were the most important non-timber forest produce species.

Table 7 shows the density of cut and lopped trees in different girth classes in the three areas. The girth class of less than 30 cm was found to be most affected in both the disturbed forests of MTR and BWLS followed by 30 cm to 60 cm girth class. Comparatively, the pressure was not very high on 60 cm and above girth classes. In the undisturbed forest (UF) however, it was the 30 cm to 60 cm girth class which was most affected. Figure 2 shows the lopping and cutting pressure on recruitment and tree classes in the disturbed and undisturbed forests *viz*., DF1, DF2 and UF. Although more than 50% of the area in both disturbed forests was affected due to grazing by livestock and weed proliferation the mean score for

'grazing and weed' was highest for the disturbed forest (DF1) of MTR. It was found that 25-50% of the disturbed forests were affected by cutting and lopping of trees by the local people. The forest of BWLS (DF2) however, had highest cutting and lopping pressure. For the undisturbed forest (UF) however, the mean scores for both the parameters were less than one. The difference in disturbance scores for both parameters were found to be significant at $p<0.01$ (Table 8). No significant difference in grazing and weed abundance was found between the disturbed forest of MTR and BWLS. However, cutting and lopping pressures in DF1 and DF2 were significantly different ($p<0.01$). Moreover, the scores of both the parameters for UF were significantly different ($p<0.01$) from those of the disturbed forests (Table 9).The impact of anthropogenic activities was also seen in the significantly lower ground cover (<25%) in the forest around the villages, both in MTR and BWLS. In the undisturbed forest which was free of all pressures, the ground cover was more than 50 percent .

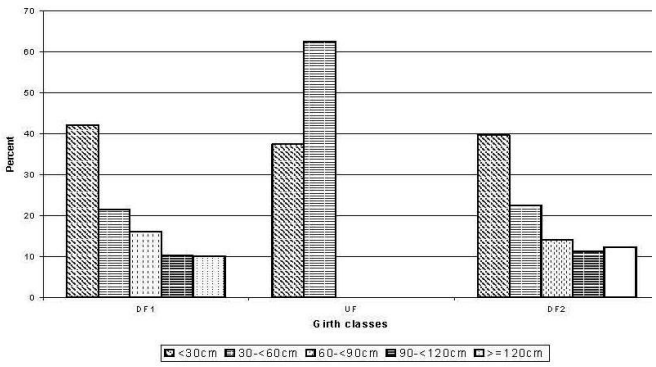

Figure 2. Percentage of cut and lopped trees in different girth classes in disturbed and undisturbed forests of Melghat Tiger Reserve (MTR) and Bori Wildlife Sanctuary (BWLS). DF1, DF2 and UF as in Figure 1.

Table 9. Mann-Whitney U-test values for disturbance scores in disturbed and undisturbed forests of Melghat Tiger Reserve and Bori Wildlife Sanctuary.

Parameters	DF1 and UF	DF1 and DF2	UF and DF2
Grazing & Weeds	-11.0944 *	-0.7218 **	8.4932 *
Cutting & Lopping	-10.6952 *	-4.7457 *	-9.5088 *

* $p<0.01$; ** $p=0.47$

DISCUSSION

Anthropogenic activities in and around PAs result in biotic pressure and consequent degradation of forests. Grazing by domestic livestock is one of the major causes of forest degradation in India. Other factors like deliberate forest fires, felling / lopping of trees for fuelwood, fodder and timber as well as NTFP collection by local people also affect the forest structure. Findings of this study also reveal that human activities in MTR and BWLS have resulted in overall low tree densities and diversity in the disturbed forests (DF1 and DF2). Distribution of trees in different girth classes showed a positive trend, with highest density of trees in GBH class <30 cm (recruitment class). The next highest density was in GBH class 30 cm to <60 cm, in disturbed forests of Melghat (DF1) and Bori (DF2). This is because of coppicing of cut trees, especially teak and at times tendu (in BWLS). In the undisturbed forest (Gugamal National Park and Tourism Zone of MTR) however, all human activities have been stopped since the 1970's. This forest is managed only for wildlife. Consequently it continues to be an old forest, with negligible disturbance caused by human activity. Therefore, it was 30 cm to <60 cm GBH class which had the highest density in this forest. Thus, it can be expected that if the human pressure is reduced through protective measures the presently disturbed forest will recover and in due course its structure will become similar to that of the undisturbed forest. When the data from permanently marked plots of 1 hectare each (collected by the MTR Research Wing during 1982 to 1994), were used for comparing trends in densities of trees, it was found that over this period, densities of majority of the tree species used by the local people had declined in disturbed forest of Melghat (DF1), however they showed slight increase in the UF as a result of protection. As similar data for BWLS was not available these trends in the three forests could not be compared.

The comparison between the disturbed (DF1 and DF2) and undisturbed (UF) forests showed that as many as 32 tree species were common between them. The undisturbed forest showed the highest tree species diversity ($H' = 2.42$). Individuals of these species were more evenly distributed ($E = 0.62$) in the undisturbed forest than in the disturbed forests. Since both diversity and evenness are indices of the level of disturbance, the higher values for undisturbed forest (UF) show the low or negligible disturbance or pressure as compared to disturbed forests of Melghat (DF1) and Bori Wildlife Sanctuary (DF2).

However, the lower diversity values of MTR and BWLS forests as compared to those of other tropical forests (Knight 1975, Saxena and Singh 1982), may be attributed to the fact that most of these areas have been worked for timber, especially teak, since the 19th century. Consequently these forests were dominated by teak. In addition to teak there were other associate species *viz., Terminalia tomentosa, Ougeinia oojeinensis, Lagerstroemia parviflora*, etc., as can be seen from the importance value indices (IVI) of tree species.

As far as the regeneration class was concerned, the seedling densities in disturbed forests of Melghat (DF1) were significantly ($p<0.001$) lower compared to undisturbed forests (UF) and disturbed forests of Bori (DF2). The number of saplings and seedlings per unit area help us assess the regeneration potential in different forest types (Saxena and Singh 1982). The higher seedling density of the undisturbed forests therefore, can be attributed to the protection against all anthropogenic activities. The forests of BWLS also had higher seedling density compared to MTR forest probably due to lower livestock pressure. MTR however, has a large population of Gawli livestock leading to high cattle densities. Moreover, the cattle belonging to the Gawlis graze deep in the forest, especially during monsoon and early winter, i.e., the time when the seeds are germinating and the seedlings and saplings are growing. Thus, high livestock density along with the grazing pattern had a negative impact on the regeneration of seedlings in MTR forest. Fox (1983) also reported that livestock grazing combined with fodder collection was a major cause of destroying and degrading forest resources in the Middle Hills of Nepal.

Regeneration and recruitment ratios of most commonly used tree species were observed. The species were *Anogeissus latifolia, Ougeinia oojeinensis, Terminalia tomentosa, Buchanania latifolia, Madhuca indica* and *Diospyros melanoxylon*. While the regeneration rates of *Anogeissus latifolia* and *Ougeinia oojeinensis* were markedly lower in both the disturbed forests, *Terminalia tomentosa* had a low regeneration status in disturbed forests of MTR. The recruitment rates (less than 30 cm GBH class) of these species, except *Ougeinia oojeinensis* were higher in the disturbed forests due to coppicing of cut stumps. Two of the NTFP species *viz.*, *Buchanania latifolia* and *Madhuca indica* had no representation in the seedling class. This was probably because both these species were under pressure due to collection of the fruits of these species. Apart from that both species are slow growing and naturally occur in low densities. These factors therefore, resulted in reducing their success of regeneration. Slow growth and low abundance could also be the factors responsible for their apparently poor regeneration in the undisturbed forest. Here it is important to mention that the agro-pastoralists return to MTR at the onset of the monsoon and their cattle together with the local cattle graze in the forest (DF1). This has an adverse impact on the ground cover and results in higher seedling mortality. The frequency of both these species, in recruitment and tree classes was found to be comparatively higher in BWLS.

Diospyros melanoxylon also is an important NTFP species, especially in BWLS, where the local people collect its leaves under the supervision of the Forest Department. To enhance the production of tender new leaves the local people usually cut the main stem of this tree. This could be the reason for the high percentage of its stems in the recruitment class in disturbed forest of Bori (DF2). The local people also eat its fruit however it does not have any commercial value. Consequently small quantities of its fruit are collected, thus allowing the species to regenerate. Except for the two NTFP species whose seeds are collected, all the other species were found to be regenerating. Most of these species showed low recruitment success. *Buchanania latifolia* and *Madhuca indica* seemed to be the worst affected with almost no regeneration which may directly affect their long term survival, and cause local extirpation.

The impact of people's dependence on the forests for fuelwood, timber and fodder for livestock was reflected in the density of cut and lopped trees in different girth classes in the disturbed forests of Bori and Melghat. The pressure however, was found to be highest on 'recruitment class' (<30 cm GBH) followed by the 'pole class' (30 cm to <60 cm GBH), as these were used for fuelwood and therefore regularly exploited. This girth class is also exploited for small timber which is used for fencing etc. The 90 cm and above girth classes also showed cutting pressure in the disturbed forests of MTR and BWLS. This is because during monsoon and winter months, large logs of wood are kept burning overnight in the households. Wood is also stored for the monsoon so people cut down larger girth trees instead of collecting fallen wood. Moreover, this girth class is also affected due to extraction of timber in forestry operations in the recent past.

However, in the undisturbed forest (UF) trees in 30 cm to <60 cm girth class were found to be most affected. This was due to a labour camp within the NP, who were using timber both for fuelwood as well as for lighting fire at night to keep the wild animals away. Thus the

'pole class' was more suitable for their requirements. The 60 cm and above girth classes were found to be unaffected in the absence of any anthropogenic pressure in the undisturbed forest. It was seen that while the trees were under pressure both for cutting and lopping, a larger number of the trees were affected by the cutting. The overall impact of biotic pressure on the forest was in the form of lower ground cover, higher weed abundance, and low seedling densities in both the disturbed forests i.e., DF1 and DF2. In the long run the degradation of forest and inadequate regeneration is likely to impede the survival of good quality forest and adversely affect the faunal diversity and richness unless steps are taken to reduce these pressures.

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