The vegetation composition, diversity, and structure of tropical montane forests (*Shola*) in the Palni Hills: Analysing the impact of disturbances

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Introduction

Tropical Montane Forests (TMFs) harbour a high biodiversity and are characterized by exceptionally high levels of endemism, thus making them a conservation priority worldwide (Bruijnzeel 2001, Hamilton et al. 1995). The TMFs are considered to be among the most threatened tropical forest of the world (Hamilton et al. 1995, Aldrich et al. 1997, Bubb et al. 2004). Most of them are fragmented remnants of the original forests (Gentry 1995, Hamilton et al. 1995, Aldrich et al. 1997). In India, montane forests occur in the Himalayas, north-eastern India, and in the Western Ghats, covering almost 8% of the total forested area of the country (Lal 1989).

The Western Ghats of India, 1 of 25 biodiversity hotspots of the world (Myers 2000), is facing several threats to its biodiversity due to human impact (Pramod et al. 1997). The TMFs of the Western Ghats occur at elevations of 1,400–2,400 m and are better known as the *Shola* forest locally (Bunyan et al. 2012, Robin and Nandini 2012). The Sholas form a unique habitat of an evergreen forest interspersed with grasslands, both often separated by sharp ecotones (Matthew 1999). This montane ecosystem is characterized by high levels of endemism (Thomas and Palmer 2007).

Most of the studies and research conducted at the Shola forest are of a descriptive nature and there are very few studies concerning climate change, ecological restoration, and the major threats faced by this very unique landscape (Robin and Nandini 2012).This study aims to understand the impact of anthropogenic pressure on the composition and structure of TMFs of the Palni Hills in the Western Ghats.

Materials and Methods

The study took place in the Palni Hills, an eastern offshoot of the Western Ghats and lay between 10°5' – 10°25' N latitude and 77°15' – 77°50' E longitude, covering an area of 2,068 km^2 with a maximum length and width of 65 km and 40 km, respectively (Matthew 1999) (Figure 1 for a detailed map, see Juyal, Dutta, and Schmerbeck this proceedings, pp 9–13). These hills fall into two geographic zones — the Upper and the Lower Palnis. This study was carried out in the Upper Palnis. These ranges from an average altitude of 1,000 m to 2,200 m elevation, cover an area of approximately 385 km^2 (Matthew 1999). The study area included the Kodaikanal and the Poombarai ranges, both of which fall under the Kodaikanal Forest Division. The mean monthly temperature ranges from 12 °C to 23 °C in summer and 8.3 °C to 17.3 °C in winter. Kodaikanal receives on average an annual mean precipitation of 2,800 mm (IMD Data 1901–2000). The Palni Hills are also subjected to regular storms and cyclones (Rawat et al. 2003).

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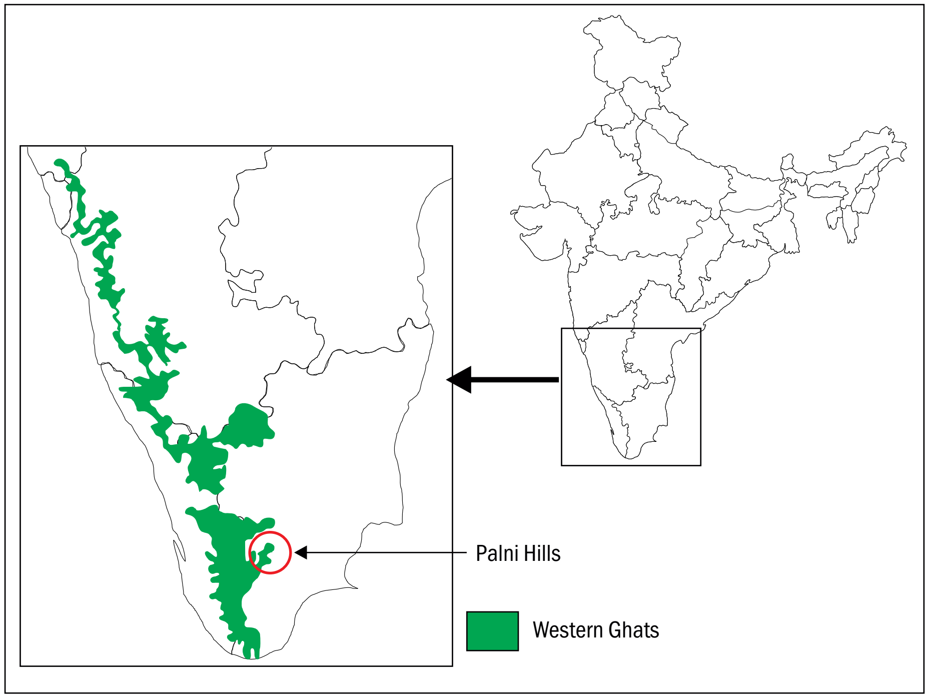

Figure 1: Map of the Western Ghats and study area Palni Hills (http://www.mapsofindia.com/)

An equal number of low- and high-disturbed Sholas were selected on northern and southern expositions with two replicates for each exposition based on information from local experts (Tanya Balcar and Robert Stewart, personal communication). Low-disturbed sites were the ones that had not been under high levels of anthropogenic disturbance since at least the past 20 years, while the high disturbed were being utilized for regular fuel wood collection. A total of 48 plots were established with six plots in each of the eight forest stands. At each of the sites, two transects were laid at a distance of 20 m from each other. A distance of 20 m was also maintained between the plots and from the edge of the forest to avoid edge effect. On each transect, three sample points were installed. Each sample point consisted of one square plot of 5 m × 5 m (25 m^2) and five circular nested plots (7 m^2, 20 m^2, 50 m^2, 100 m^2, and 500m^2). All plots of one sample point had the same centre. In the square plot, the coverage of all life forms in three height layers (under storey≤1.3m, middle storey>1.3≤5m, canopy>5m) were assessed while the circular plots served the assessments of trees. The parameters assessed in each of the plots are listed in Table 1.

Results and Discussion

A total of 119 plant species belonging to 55 families were found in the under and middle storey of all the plots. Ninety-two species belonging to 50 families were found in the high disturbed areas while 88 species belonging to 45 families were found in the low disturbed areas. In the canopy, layer *Cinnamomum wightiana, Litsea wightiana, Schefflera racemosa, Syzygium densiflorum, and Elaeocarpus variabilis* were the most common species found in both high and low disturbance categories. In both the areas, a major proportion of species found were tree species (Figure 2).

The high disturbance areas had a higher proportion of herb and grass species while the low disturbance areas had a higher proportion of

Table 1: Plant categories and recorded parameters assessed in the different circular plots

Plot Size	Vegetation strata studied	Variables collected
5 m × 5 m A=25 m²	Under storey ≤1.3 m Middle storey >1.3 m–≤5 m Canopy>5 m	*Plot*: GPS Coordinates, elevation, exposition, slope, layer-wise vegetation coverage, total coverage, signs of disturbance *Species*: Botanical names, species coverage, damages
r= 1.49 m A= 7 m²	Seedling 1: trees <30 cm height	*Individuals*: Botanical name, number of individual under each damage
r=2.52 m A= 20 m²	Seedling 2: trees 30 cm–≤130 cm height	
r=3.99 m A= 50 m²	Sapling 1: trees height >130 cm height and dbh ≤3 cm	
r=5.64 m A= 100 m²	Sapling 2: trees >130 cm height and dbh >3 cm–≤7 cm	
r= 12.52 m A= 500 m²	Mature trees dbh >7 cm	*Individuals*: scientific name, dbh, height of first living branch, height of tree and damages

Notes: dbh: diameter at breast height; A: area; r: radius

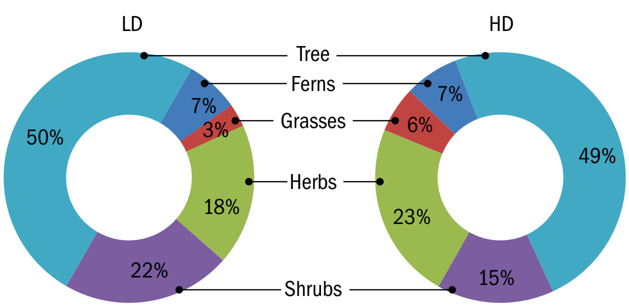

Figure 2: Percentage of growth forms found in low and high disturbed areas

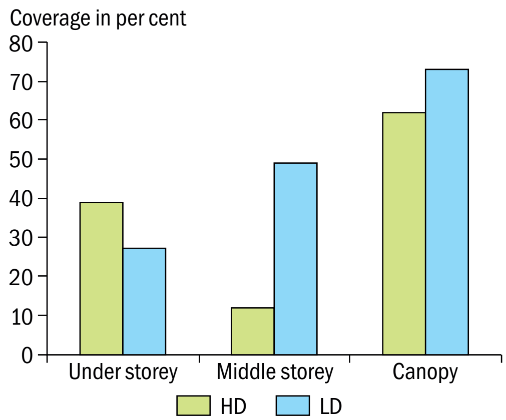

Figure 3: Percentage of coverage in under storey, middle storey and canopy in high and low disturbed areas

shrubs. This suggests that with high disturbance the shrub layer is negatively impacted and under low disturbance shrub species richness increases (see Bunyan et al. 2012). The diversity was significantly higher in the under and middle storey of low disturbed areas ($p<0.01$). However, the two different treatments showed no significant difference ($p<0.01$) in the diversity of the canopy. The reason for this might be that these forests were intensively used at times when the canopy trees were in the seedling and sapling stage which triggered a selection for species resistant to this disturbance and reduces diversity thereby (see Petraitis et al. 1989).

A significant difference was found between the treatments in the tree coverage of the middle storey and under storey (Figure 3) which suggests the adverse impact of disturbance on the middle storey. The number of regenerating trees per hectare in seedling and sapling categories was found to be significantly higher in the low disturbed areas (Figure 4).

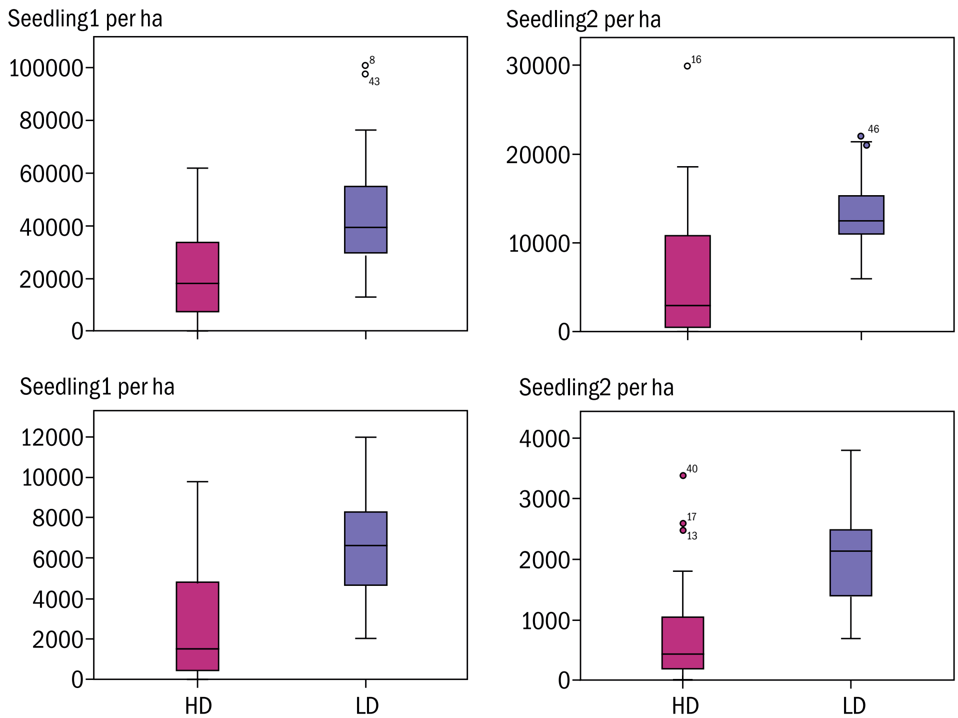

Figure 4: Regenerating individuals per ha in seedling and sapling categories of low and high disturbed plots

The proportion of plots with individuals of sapling 1 and 2 showing signs of cutting and grazing was higher in HD areas while the seedlings were mainly affected by grazing (50% of the plots). However, the difference between the two treatments was not significant. All saplings were affected by cutting and grazing, where cutting signs were almost equal (60% plots) for sapling 1 and 2 in HD. However, in comparison very less cutting was present in LD (8% plots in sapling 1 and no cutting in sapling 2). Grazing signs varied with 38% and 62% in sapling 1 and 2, respectively, of HD and only sapling 2 showed grazing signs in LD (24%). *Psychotria nilgiriensis var. astephana, Pavetta montana*, and *Maesa indica* were the tree species that were mostly affected by cutting in both sapling categories. *Pavetta montana* was the most grazed tree species in the sapling category followed by *Neolitsea zeylanica*. The grazed individuals in seedling layer could not be identified due to non-identification of species because of no leaf mass present. In the plots of the HD areas, 75 individuals were found coppiced with highest number of individuals between diameters at root collar (drc) categories of 3–9 cm and 12–21 cm, whereas only three coppiced individuals were found in low disturbed areas.

In the canopy layer, a total of 1,138 trees (dbh >7cm) were recorded in the entire study area with a dbh ranging from 7.1 to 210 cm. However, the number of individuals found was not significantly different between HD and LD areas (568 and 570, respectively), while most individuals fell within low diameter classes (Figure 5).

A high percentage of early successional species was found in both treatments and in all categories of seedling, sapling, and mature tree layer (Table 2). Their presence in the mature tree layer indicates the presence of disturbance even in the LD areas at the time when these trees were seedlings.

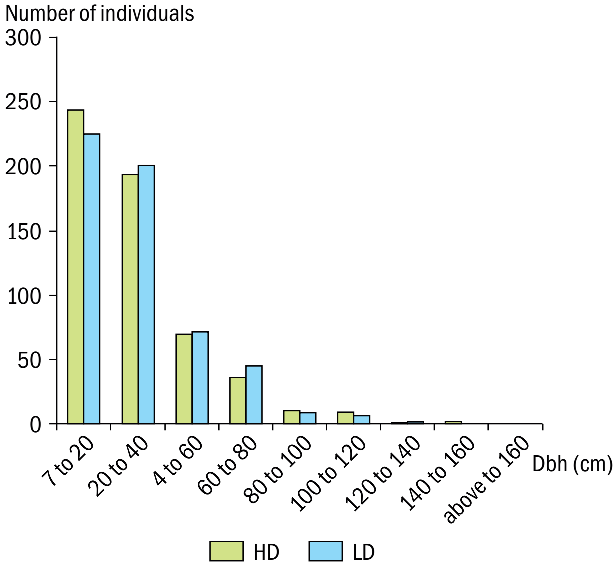

Figure 5: Number of mature trees found in different dbh classes in low and high disturbed plots

disturbance. The historic levels and kind of disturbance are not known but it can be assumed, according to the high presence of early successional species in the canopy of the low disturbed sample plots, that these stands had faced disturbances earlier. However, the absence of late successional tree species in all layers could also be caused by the absence of such species in the regional species pool. If the current composition of the matured trees is a result of anthropogenic historic disturbance regime or represent a somewhat natural status triggered by a strong presence of natural disturbances over evolutionary times, needs to be clarified in future studies.

Table 2: Proportion of species in different categories according to guilds in high and low disturbed areas [N=Native, E=Exotic (information about guild for different species was taken from Tanya Balcar and Robert Stewart, personal communication)]

	Guilds								
	Early-successional		Mid-successional		Late-successional		Edge		Unknown
	N	E	N	E	N	E	N	E	
High disturbed areas									
Seedling layer	68%	3%	20%	0%	0%	0%	0%	0%	9%
Sapling layer	53%	5%	31%	0%	0%	0%	2%	0%	9%
Mature tree layer	78%	9%	12%	0%	0%	0%	0%	0%	1%
Low disturbed areas									
Seedling Layer	57%	0%	28%	0%	0%	0%	1%	0%	14%
Sapling Layer	52%	1%	28%	0%	0%	0%	0%	0%	19%
Mature tree layer	68%	2%	26%	0%	0%	0%	1%	0%	3%

Conclusion

Disturbance reduces species and structural diversity of the studied TMF as well as the number of regenerating trees while the diameter distribution of mature trees was least affected by the disturbance regime (Figure 4). However, both treatments are under some

References

Aldrich M, C Billington, M Edwards, R Laidlaw, 1997. ‘Tropical Montane Cloud Forests: An Urgent Priority for Conservation’, *WCMC Biodiversity, Cambridge. Bulletin No. 2*. Available at ansatte.uit.no/lni000/Statistikk/pdf/Twinspan%202.pdf (last date of access: 12 May 2014).

Bruijnzeel L A, 2001. 'Hydrology of Tropical Montane Cloud Forests: A Reassessment', *Land Use and Water Resources Research* 1(1).

Bubb P, 2004. *Cloud Forest Agenda*. UNEP World Conservation Monitoring Centre.

Bunyan M, S Bardhan, and S Jose, 2012. 'The Shola (Tropical Montane Forest) Grassland Ecosystem Mosaic of Peninsular India: A Review', *American Journal of Plant Science* 3: 1632–39.

Gentry A H, 1995. 'Patterns of Diversity and Floristic Composition in Neotropical Montane Forests', *Biodiversity and Conservation of Neotropical Montane Forests*, pp. 103–26.

Hamilton L S, J O Juvik, F N Scatena, 1995. *Tropical Montane Cloud Forests: Ecological Studies*. New York: Springer Verlag.

IMD Data: Monthly Mean Maximum and Minimum Temperature and Total Rainfall Based upon 1901–2000 Data. Available at www.imd.gov.in (last date of access: 13 April 2013).

Lal J B, 1989. *India's Forests: Myths and Reality.* Dehra Dun, India: Nataraj Publishers.

Matthew K M, 1999. *Flora of the Palni Hills:* Part One. Rapinat Herbarium, Trichurapalli, India.

Myers N, 2000. 'Biodiversity Hotspots Revisited', *Bioscience* 53: 796–97.

Petraitis P S, R E Latham, and R A Niesenbaum, 1989. 'The Maintenance of Species Diversity by Disturbance', *Quarterly Review of Biology* 64: 393–418.

Pramod P, N V Joshi, U Ghate, and M Gadgil, 1997. 'On the Hospitality of Western Ghats Habitats for Bird Communities', *Current Science* 73(2): 122–27.

Rawat G S, P V Karunakaran, V K Uniyal, 2003. 'Shola Grasslands of Western Ghats: Conservation Status and Management Needs', *ENVIS Bull Grassland Ecosystem Agroforestry* 1(1): 57– 64.

Robin V V and R Nandini, 2012. 'Shola Habitat on Sky Islands: Status of Research on Montane Forests and Grasslands in Southern India', *Current Science* 103(12): 1427.

Thomas S M and M W Palmer, 2007. 'The Montane Grasslands of the Western Ghats, India: Community Ecology and Conservation', *Community Ecology* 81: 67–73.