Characterization of Shola forest-grassland mosaic in Upper Palni Hills: What makes the edge?

Sandeep Juyal*[1], Charvi Tanya Dutta[1], and Joachim Schmerbeck[1]

[1] Department of Natural Resources, TERI University, New Delhi, India

Introduction

The evergreen tropical montane forest and adjacent grasslands of Western Ghats are a distinct vegetation mosaic (Thomas and Palmer 2007, Davidar and Mohandass 2007, Somasundaran and Vijayan 2008, Jose et al. 1996). According to Davidar and Mohandass (2007), Somasundaran and Vijayan (2008), Jose et al. (1994, 1996), Meher-Homji (1965, 1967), Bor (1938), and Noble (1967), this tropical montane forest locally referred to as *Sholas*, are stunted forests with massive trunks that rarely go above 15 metres. Shola forest-grassland mosaics usually appears in isolated patches on top of hills in the Western Ghats and this feature is one of the reasons for their high speciation and high endemism (Robin and Nandini 2012). The transition from grassland to Shola is abrupt with a thick tree and shrub growth, creating a sharp ecotone.

Jose et al. (1994) state that the Shola forest-grassland vegetation of high hills in the Western Ghats remained in equilibrium for decades. It implies that they are highly developed vegetation types and have attained stability over the years under the same climatic regime. Meher-Homji (1965, 1967) suggests that frosts coupled with dry spell confines the woody species to the valleys and folds of hills. Meher-Homji (1965, 1967) supports this by saying that grassland species are of temperate or subtropical origin while the forest species are of tropical region. The author explains this distribution by frost-induced stress as tropical species are not able to establish in open grasslands. However, as cold air is heavier, it tends to accumulate in the valleys and folds of hills and therefore the damage from frost should be high in the valleys but still grassland occupies the open space and Shola remains in valleys. Ranganathan (1938) and Gupta (1960) considered these forests and grasslands to be edaphic climaxes though there are distinct edaphic microclimatic differences found between the Shola and grasslands (Jose et al. 1994). Bor (1938) and Noble (1967) see these grasslands as sub-climax maintained by disturbance. Bor (1938) formulated the fire hypothesis that states that these grasslands are the outcome of frequent burnings from agricultural and pastoral activities introduced by early human settlers. This hypothesis was favoured amongst ecologists as there was no conclusive evidence for the frost hypothesis (Jose et al. 1996). On the other hand, a pollen analysis shows that grasslands were present long before human settlements (Sukumar et al., 1993). If grassy vegetation is a successional stage prior to forest (Thomas and Palmer 2007) then habitats suitable for grasslands are created by natural or human disturbance and therefore a natural grassland would only appear where climate and edaphic characteristics do not support the establishment of forest (Bond and Parr 2010). To understand the reasons for the appearance of these complex vegetation types, this study looks into the effect of disturbance on the structure of Shola forest-grassland.

* Corresponding author: san.juyal86@gmail.com, juyalsandeep1@gmail.com

Materials and Methods

Also this study took place in the Palni Hills (Figure 1) (see for details Juyal et al. in this proceedings). The Upper Palni Hills have an average elevation of around 2,200 m though individual peaks go up to 2,500 m elevation and more (Matthew 1999, Grossman and Durran 1984). They are an undulating plateau interspersed with occasional peaks along with a few ravines or valleys (Matthew 1999).

Three edges on two sites with vertical edges of Shola forest-grassland on south-facing slopes were selected to see the change of vegetation and disturbances on the same elevation from grassland to Shola. A total of nine sampling transects (3 transects in each edge) with a length of 150 m were established (Figure 2) with a distance of 20 m. Each transect consisted of five plots of 5 m × 5 m plots with nested circular plots of area 7 m^2 and 20 m^2. These were nested in three circular plots of 50 m^2, 100 m^2, and 500 m^2. In the square plot the coverage of all life forms in three height layers where assessed while the circular plots served the assessments of trees. The disturbance signs (fire, grazing/browsing, cutting, and trampling) and damage signs on species and plot level were also recorded in all plots (for detailed methodology see Juyal et al. in this proceedings).

Figure 1: Map of the Palni Hills
Source: Google maps (Last accessed on: April 14, 2014)

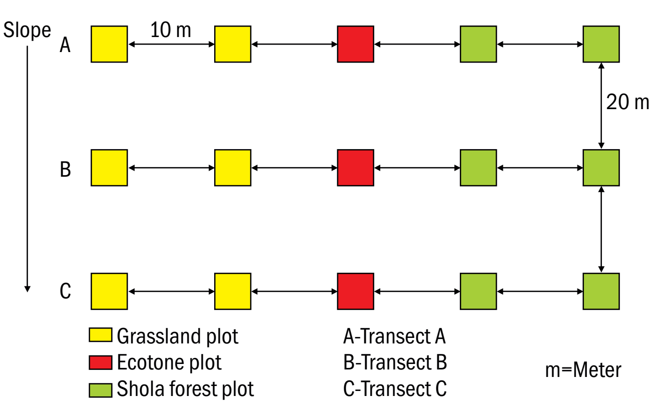

Figure 2: Transect layout in Shola forest-grassland

Results and Discussion

A total number of 185 vascular plant species were found in the grassland, ecotone, and Shola out of which 54 species were found in grassland, 120 species in ecotone, and 116 species in Shola. In grassland, only 22% of the total species were grasses. The remaining species consisted of herb, perennial herb, and shrub species. Similar results are reported by Meher-Homji (1967) showing low percentage of grass species and high percentage of herb and shrub species. The Shannon Diversity Index was significantly different in all vegetation types ($p=0.01$). The diversity in the ecotone was highest in the middle layer (>1.3m – ≤5m) and Sholas had the highest diversity in the lower (≤1.3m) and upper layers (>5m).

Grasslands showed the highest frequency of disturbance while fire was predominant in grassland and cutting as well as trampling in Sholas (Figure 3). The diversity was lowest in the grassland, which could be due to the presence of frequent fires here, which can affect “plant species diversity by eliminating the disturbance sensitive species” (Peterson and Reich 2008).

Dense regeneration was found in edge and Shola, but hardly in grassland; however, the number of individuals differed much between grassland plots (Table 1). The lack of regeneration in grasslands is likely to be caused by regular fires. This difference in regenerating individuals in lower and middle layer can be due to the presence of disturbance like grazing/browsing

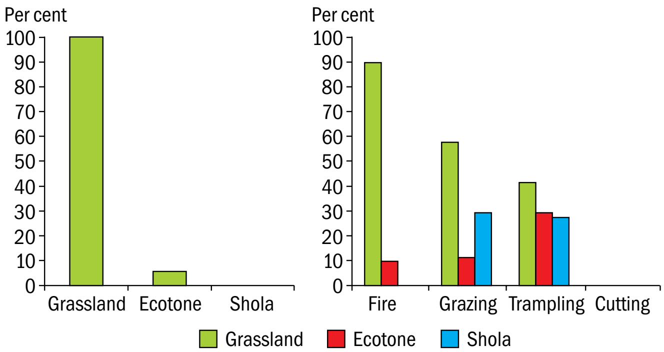

Figure 3: Proportion in percent of A) trees with fire signs and B) plots with signs of disturbance

which can lead to a poorly developed middle layer (>1.3m) and change in vegetation structure (Gill 2000). *Vaccinium leschenaultia, Rhododendron arboreum* (sp. nilagiricum), *Syzygium densiflorum*, and *Daphniphyllum neilgherrense* were the four species found regenerating in the grassland plots. They are light demanding and pioneer species (NCF and VCT 2006) and are usually found on the Shola grassland ecotone. The same species were found in high abundance as matured trees (> 7cm dbh) in the interiors of the Sholas which suggest the presence of disturbance in the past (Pickett and White 1985). The basal area results howed a significant difference between three vegetation types with 39.4m^2/ha in grassland, 158.71m^2/ha in the edge and 592.29 m^2/ha in Shola forest. *Rhododendron arboreum* (ssp. *nilagiricum*) was the only tree species that was found with mature trees of dbh >7cm and accounted for all the basal area in the grassland.

Conclusion

The abundant fire signs on grasslands indicate a relative frequent occurrence of fires here. The decline of fire evidence towards the interior of the Sholas indicates that the fires stop in the ecotone. The distinction between the origin and maintenance of the grassland needs to be taken in consideration (Meher-Homji 1967) as grasslands might have originated under different climatic conditions, and forest would establish under present conditions if not kept from doing so by the regular occurring fires. The frequency and time since disturbance (fire) influences the ability of trees to establish in grassland (Pickett and White 1985). In the presence of adequate moisture and edaphic characteristics, Shola

Table 1: Total number of individuals of tree species found per hectare in different circular plots

Seedling 1 (Plots)	Mean individuals/ha	SD	Sapling 1 (Plots)	Mean individuals/ha	SD
G2	87.30	263.49	**G2**	0	0.00
G1	69.84	211.11	**G1**	44.44	133.33
E	4,990.47	2,579.19	**E**	4,466.67	2,357.97
S1	3,738.10	1,130.16	**S1**	4,733.36	2,000.00
S2	3,438.10	928.57	**S2**	5,355.65	2,342.60
Seedling 2 (Plots)	**Mean individuals/ha**	**SD**	**Sapling 2 (Plots)**	**Mean individuals/ha**	**SD**
G2	61.67	185.00	**G2**	33.33	70.71
G1	42.78	129.44	**G1**	0	0
E	1,339.44	490.56	**E**	2,100.00	1454.30
S1	1,428.33	566.11	**S1**	1,855.57	946.19
S2	1,419.44	434.44	**S2**	1,888.86	600.93

Notes: (***G, E*** and ***S*** stands for grassland, ecotone, and shola, respectively, ***1,2*** indicate the plot location with 1 being the plot close to ecotone and 2 being far from ecotone on a transect, ***seedling 1, seedling 2 and sapling 1, sapling 2*** are the circular plots with area 7m^2, 20m^2, 50m^2, and 100m^2, respectively, ***SD***= standard deviation.)

trees hold the potential to colonize in grassland (Bor 1938, Meher-Homji 1967, Favier 2004). Once the Shola trees manage to establish in the grassland, with time they will be able to improve the edaphic characteristics as well (Bor 1938).

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