Land cover change in Himalaya with special reference to forest disturbance: A case of Bharse area, Lesser Himalaya, West Central Nepal

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The status of forests in Nepal is often expressed in terms of the extent of deforestation (World Bank 1978, Bishop 1990, UNEP 2001). However, in case of the hill forests extraction of timber, lopped for firewood and foliage, litter collection and grazing degrade forest structure and create land cover types that are intermediate between intact and cleared forests. Such forests which are supplying the basic needs of local people and continuing their existence help to protect biodiversity that existed locally for a long time. This study refers such an intermediate type of forest to as disturbed forest. The term 'degradation' has been used for the loss of biomass from the forest floor with undesired effects on the forest structure. The disturbance caused by extraction of timber, lopping for firewood and foliage, litter collection and grazing etc. are referred to as anthropogenic disturbance.

The aim of this study was to quantify the land cover change between 1958 and 2002, using topographical maps (1958), aerial photographs (1992) and field observation in 2002 in the Bharse area, Gulmi district, western Nepal. Five managed forest plots, within the area, which remained virtually unchanged during the period were selected to measure the disturbance intensity and species diversity indices for trees. We believe that both intensity of disturbance and diversity indices for trees should differ despite the forest cover remained unchanged. Therefore, we determined the disturbance intensity (DI) and analyzed the diversity indices for tree species of each selected forest to evaluate the influence of human disturbance in the forest floor.

Land cover change during 1958-2002 was analysed in the same area using Geographical Information System as an analytical tool. Seventy-five circular plots belonging to five forests; Thaple (TL), Raniban (RB), Lurung Bhitta (LB), Chiureko Lek (CL) and Raiker (RK) were sampled to measure the disturbance intensity and diversity indices. Each plot covered 50 m^2 area, In each plot, floristic composition (total number of woody species), stand structure (density, species type and diameter at breast height (DBH) at 1.3 meter height (for stands with diameter greater than 5 cm) and succession (number of tree species less than 5 cm DBH and height greater than 50 cm) were measured. Further, the number of stumps, the number of trees lopped for firewood (tree with at least one cut branch exceeding 5 cm diameter), and foliage were counted in each plot to determine the cutting disturbance intensity. The DBH of removed trees was calculated from stump height and diameter at cut point (Khatry-Chhetry and Fowler 1996). Each species encountered was identified at first by local name in the field and the botanical name was identified at the National Herbarium Center, Godavari, Kathmandu. Evidence of grazing in each sample plot was determined from the presence of cattle, dung, browsing, trampling and grazing traces.

To determine the DI from the cutting pressure, three variables were calculated as proportions; (a) proportion of removed basal area, (b) proportion of removed trees and (c) proportion of lopped trees. The weights were subjectively assigned based upon the relative contribution for the removed ground biomass loss from the forest and their effects on forest structure and composition (Khatry-Chhetry 1997, Acharya 1999). The removed basal area is strongly correlated with the removed biomass, so, it is considered to be important (W = 0.50). Lopping for firewood and foliage represents the smallest loss of biomass amount and its effect is quite small among the selected variables of this study. So it was assigned the lowest value (W = 0.1666) (Khatry-Chhetry 1997).

$$\mathbf{DI} = \sum_{i=1}^{n} (DVi * Wi)$$

Where,
DVi = i^{th} disturbance variable
Wi = Assigned weight for ^{i}th variable

The cutting disturbance intensity is a relative index of a weighted additive form (Oat 1978) with a theoretical range of zero (no disturbance) to one (maximum disturbance).

Grazing intensity was determined from the qualitative data observed during the field work. Evidence of grazing in each plot was determined from the presence of cattle, dung, browsing, trampling and grazing traces, ranking 0%, 25%, 50%, 75% and 100%. The rank percentage of grazing was changed to the percentage of grazing area in the forest level dividing the sum of rank of each forest by the total number of sampled plots of the same forest.

The different indices of species diversity, i.e., species richness (number of species per unit area), evenness (distribution of abundances among the species) and diversity index were calculated for succession and trees in five forests (Margalef 1958, Shannon and Weaver 1949, Simpson 1949), which are the most commonly used measures of diversity indices by ecologists.

The forest land increased by 3.31 km^2 (33%) whereas agriculture and shrub lands decreased by 1.21 km^2 (19%) and 2.14 km^2, respectively, between 1958 and 1992. The shrub land increased by 0.85 km^2 (16%) whereas agriculture and forest lands decreased by 0.80 km^2 (16%) and 0.04 km^2 (<1%), respectively, between 1992 and 2002. The other types of land cover (landslides and water bodies) occupied minimal area (<0.2%) of the Bharse area for periods 1958, 1992 and 2002.

Among the five forests, the highest cutting disturbance intensity of 0.141 was determined in forest TL whereas the lowest value of 0.049 was found for forest RB. Forest RK occupies second highest position according to DI having a value of 0.10. The forest LB and CL have quite similar values of 0.053 and 0.058 of DI, respectively.

Grazing evidence was found only for CL, RB and TL. Almost all parts of forest TL has been affected form the cattle grazing having highest value of 58% followed by forest RB, 48%. Only 20% area of forest CL was affected from the grazing practices.

TABLE 1. Pattern of species diversity in studied forests for trees (> 5 cm DBH) arranged according to increasing level of cutting disturbance

Diversity indices	Forests				
	RB	LB	CL	RK	TL
Species richness	3.67	3.10	2.60	2.64	1.99
Shannon Weaver's Index	2.36	2.39	2.18	2.26	1.93
Simpson's diversity	0.85	0.89	0.85	0.87	0.81
Evenness (Shannon Weaver's)	0.76	0.84	0.82	0.83	0.81

Note: LB, Lurung Bhitta; CL, Chiureko Lek; RB, Raniban; RK, Raiker; TL, Thaple

TABLE 2. Pattern of species diversity in studied forests for succession of tree species (> 5 cm DBH) arranged according to increasing level of grazing disturbance

Diversity indices	Forests				
	LB	RK	CL	RB	TL
Species richness	3.54	2.83	2.52	2.87	1.55
Shannon Weaver's Index	2.43	2.56	2.35	2.33	1.86
Simpson's diversity	0.88	0.90	0.87	0.0.87	0.83
Evenness (Shannon Weaver's)	0.81	0.90	0.89	0.80	0.85

Note: LB, Lurung Bhitta; CL, Chiureko Lek; RB, Raniban; RK, Raiker; TL, Thaple

The studied forests of Bharse area have relatively low disturbance as compared to the surrounding area of Kathmandu valley (Acharya 1999, Khatry-Chhetry 1997). Such differences are probably due to effective forest management practices of the local inhabitants and increased forest cover in private land between 1958 and 1992. Hence, effective management practices are crucial in order to reduce the disturbance intensities.

According to field data, on disturbance intensity and the types of disturbances, which were collected during the fieldwork, the five forest patches were categorized as affected by illegal timber extraction (LB), illegal timber extraction and grazing (CL), illegal timber extraction and opening for grazing (RB), opening for timber extraction (RK), and opening for both grazing and timber extraction (TL). The different indices of species diversity of vegetation for succession and trees were calculated for each forest patch to know the influence of cutting and grazing intensity on the forest floor.

The species richness for trees (> 5 cm DBH) decreases with increasing cutting disturbance (Table 1). However, no effects were seen from cutting for succession (< 5 cm DBH) compared to the value of trees (> 5 cm DBH) in respective forest patch (Tables 1 and 2). Species richness and diversity of Shannon-Weaver index were found high for succession compared to the values of trees for forests accessible to cutting (RK and LB). The above indices were low for forests opened for grazing (RB), and cutting and grazing (TL). Diversity indices for succession were high in the forest affected by cutting (RK).

The diversity indices indicate a poor regeneration of species in the forests used heavily for cattle grazing, whereas no such effects were seen for forests affected by cutting.

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